Journal of the Institute of Petroleum

VOL. 40 JUNE 1954 No. 366

CONTENTS

Accident Prevention
By T. T. MacLean

Physical Constants of a Series of Alkylnaphthalenes and Related Naphthenes. Attempts to Correlate their Structure with Physical Properties.
By B. B. Elsner

A Rapid Method for Determining the Char Value of Kerosine
By A. R. Javes and Miss C. Liddell

Carbon Residue—Conradson or Ramsbottom?

The Stability and Compatibility of Fuel Oil and Diesel Fuel. Contributed Discussion

Obituary—Robert Ashley Baldry

Abstracts 685–827

Book Reviews

Additions to Library

PRICE 10s 0D A COPY OR
£4-14-6 YEARLY *POST FREE*

Published by the Institute of Petroleum 26 Portland Place London W1

Printed in Great Britain by Richard Clay and Company Ltd Bungay Suffolk

COUNCIL, 1954–55

President

Lt.-Col. S. J. M. Auld, O.B.E., M.C., D.Sc.

Past-Presidents

Sir Andrew Agnew, C.B.E.
T. Dewhurst, A.R.C.S.
A. E. Dunstan, D.Sc., F.R.I.C.
E. A. Evans, M.I.Mech.E., F.R.I.C.
F. H. Garner, O.B.E., Ph.D., F.R.I.C.
H. S. Gibson, C.B.E., M.A., M.I.Mech.E.
C. A. P. Southwell, C.B.E., M.C., B.Sc.

Vice-Presidents

H. Hyams
F. Morton, Ph.D., D.Sc., F.R.I.C.
J. A. Oriel, C.B.E., M.C., M.A., B.Sc., F.R.I.C., M.I.Chem.E.
H. E. F. Pracy, B.A., M.I.Chem.E.
R. B. Southall, C.B.E.
G. H. Thornley, M.Sc.

Members of Council

W. S. Ault, B.A.
V. Biske, B.Sc., LL.M., F.R.I.C.
C. D. Brewer, M.I.Mech.E.
E. J. Dunstan, M.Sc., M.I.Chem.E.
E. B. Evans, M.Sc., Ph.D., F.R.I.C.
F. L. Garton, M.A., B.Sc.
A. J. Goodfellow, B.Sc., A.R.I.C.
A. C. Hartley, C.B.E., F.C.G.I., B.Sc.(Eng.), M.I.C.E., M.I.Mech.E.
B. LeQ. Herbert, B.Sc., F.R.I.C., M.I.Chem.E.
E. C. Masterson, B.Sc.
J. S. Parker, M.A., B.Sc.
A. J. Ruthven-Murray, M.A., B.Sc.
D. L. Samuel, B.Sc., A.R.I.C.
G. H. Smith, Ph.D.
A. R. Stark, B.Sc., A.R.I.C.
E. J. Sturgess, B.Sc.
W. H. Thomas, A.R.S.M.
O. F. Thompson, O.B.E.
A. T. Wilford, B.Sc., F.R.I.C.
C. G. Williams, D.Sc., M.I.Mech.E., F.R.Ae.S.
C. S. Windebank, B.Sc., M.S.

Ex-Officio

S. A. Berridge, Fawley Branch
W. H. Davies, London Branch
H. H. Ballard, Northern Branch
W. M. Stirling, A.H-W.C., A.M.I.E.E., Scottish Branch
N. W. Grey, South-Eastern Branch
E. J. Horley, South Wales Branch

Honorary Secretary

C. Chilvers, B.Sc., F.R.I.C.

Honorary Treasurer

G. H. Coxon

General Secretary

D. A. Hough, F.I.A.C.

Honorary Editor

E. B. Evans, M.Sc., Ph.D., F.R.I.C.

Editor

George Sell

Honorary Secretaries of Branches

Fawley Branch: S. A. Berridge, c/o Esso Petroleum Co. Ltd., Fawley, Southampton.

London Branch: R. F. Leach, M.A., c/o Shell-Mex and B.P. Ltd., Shell-Mex House, Strand, London, W.C.2.

Northern Branch: G. M. Davies, c/o Esso Petroleum Co. Ltd., Mode Wheel Installation, Trafford Wharf Road, Manchester 17.

Persian Gulf Branch: E. J. Sole, c/o Kuwait Oil Co. Ltd., Kuwait, Persian Gulf.

Scottish Branch: W. M. Stirling, A.H-W.C., A.M.I.E.E., Scottish Oils Ltd., Middleton Hall, Uphall, Broxburn, W. Lothian.

South-Eastern Branch: J. R. Moore, Fisher, Governor and Co. Ltd., Airport Works, Rochester, Kent.

South Wales Branch: E. J. Horley, National Oil Refineries Ltd., Llandarcy, Glam.

Stanlow Branch: V. Biske, B.Sc., LL.M., F.R.I.C., Lobitos Oilfields Ltd., The Refinery, Ellesmere Port, Cheshire.

Trinidad Branch: E. G. Everett, c/o United British Oilfields of Trinidad Ltd., Point Fortin, Trinidad, B.W.I.

THE INSTITUTE OF PETROLEUM

AN Ordinary General Meeting of the Institute of Petroleum was held at 26 Portland Place, London, W.1, on 10 February 1954, the Chair being taken by the President, H. S. Gibson, C.B.E.

The General Secretary read the minutes of the previous meeting, which were confirmed and signed as a correct record. He then read a list of members elected since the previous meeting and made various announcements.

The President, introducing the author of the paper to be presented, said : It gives me great pleasure to introduce my old colleague Mr T. T. MacLean, with whom I was associated for many years in Persia. Mr MacLean's first connexion with the petroleum industry dates back to 1917, when he went to Abadan to carry out tests on the shell stills, which were then, of course, the main piece of equipment in a refinery, and on other equipment. He afterwards returned to London, where he worked on the development of various schemes until 1920, when he left the Anglo-Persian Oil Company, as it was then known. He returned to Abadan in 1927, where he joined the Construction Department. Later he took charge of the Drawing Office, a post he held for some years, and afterwards developed an apprentice training scheme. In 1937 Mr MacLean was selected to build up a new safety organization. By that time Abadan and the oilfields had grown considerably, and the matter of safety had become very important with the great increase of labour—much of it completely unskilled. He built up a very efficient organization.

Mr MacLean carried on with that work until 1944, when he came to London as chief safety engineer of the Anglo-Iranian Oil Company, a post he occupied until 1952, when he retired. Mr MacLean has done a great deal of work for the Institute—he is the chairman of the Refining Sub-committee, and has for many years been a member of the Production Sub-committee, being engaged in the preparation of safety codes for those two branches of the industry.

The following paper was then presented :

ACCIDENT PREVENTION

By T. T. MACLEAN

THE opinions and remarks expressed in this paper on some aspects of accident prevention are based on experience gained as the chief safety engineer with the Anglo-Iranian Oil Co. Ltd. in Persia. The magnitude of the Company's undertakings and the necessity for it being self-supporting, due to its isolation, brought the safety engineers into contact with many more industries than is usual in the U.K.

Labour was engaged locally, and with the exception of such native craftsmen as carpenters and builders, all skilled men had to be trained by the Company. Raw labour consisted largely of tribesmen from the hills and the surrounding country. In many cases their desire for employment by the Company was an expedient to tide them over difficulties arising through poor harvests and the like. In consequence, there was a constant ebb and flow of labour without any previous knowledge of industry as is understood in the U.K.

Due to lack of local facilities, the Company maintained a very complete and up-to-date medical service. Within the organization it was responsible for the maintenance of dispensaries and first-aid facilities in addition to the usual medical services, also for medical control of operations which might have a detrimental effect on health. On this account there was always close co-operation between the safety engineers and the Medical Department.

TRAINING

Whenever new workers are admitted into a works, it is essential that they do not inadvertently cause a mishap resulting in injuries to themselves or others, or damage to plant. This is particularly the case in oil installations, where the risk of fire and gassing are ever-present dangers.

The need for taking such precautions has been recognized in the oil industry since its inception, and is accepted as a matter of course. On this account it is sometimes taken for granted that all employees are equally aware of the hazards which are normal to the industry. It must, however, be remembered, that new employees may not be so well informed as older hands and that the saying " familiarity breeds contempt " will on occasions be found to apply to the long-service men.

To overcome the lack of suitable labour in Persia, the Anglo-Iranian Oil Co. established very extensive training schemes, including primary, secondary, and technical schools, apprentice training shops, and adult training centres. These were concerned with the skills required to suit the learners for particular jobs, and are mentioned to make the point that although numerous qualified teachers and instructors were engaged on this work, the teaching of safety was undertaken by the safety engineers.

In the senior schools safety was taught separately, as it was considered to be equal in importance to any other subject. The attendance of a safety engineer to give lectures was considered to carry more weight than if safety was interposed with other subjects.

New employees received training in safety immediately after engagement and before being drafted into the works. At this stage the instruction was kept as simple as possible, but gave some useful hints on

avoidance of common hazards liable to be encountered by new-comers. These were told why the carrying of matches and smoking could be dangerous, and it was generally agreed that the time spent in giving this initial instruction was worthwhile. It was essential, however, for this type of instruction to be readily understandable by the learner.

In most western countries the safety engineer can assume that the apprentice has some knowledge of safety matters, but in the East it was wiser to assume he had no knowledge at all, and to start right down at ground level.

A type of accident which was fairly common some years ago will perhaps serve to illustrate this point. On a number of occasions men, hurrying to secure lifts on motor lorries, endeavoured to clamber aboard by stepping up on to one of the rear tyres while the vehicle was getting under way. The inevitable happened, and in some cases the person lost his life as the wheel passed over him. To a person accustomed to living in the U.K., an incident of this sort hardly seems possible, but other instances of similar lack of experience could be mentioned.

Cases of this nature point very clearly to the need of understanding what may be called the experience level of the men being instructed. It is on account of the knowledge gained in this respect that instruction in any sphere must start at a low level.

From time to time firms in the U.K. and other countries, where safety organizations are in operation, run competitions to stimulate interest in safety matters. One such competition takes the form of spotting unsafe situations in illustrations depicting the interior of workshops. Men are shown carrying out work of various types, and the number of subjects covered are of such magnitude that they would form better tests for qualified safety engineers rather than for specialized workers.

Although my Company used up-to-date aids, such as films, posters, synchrophones, etc., constant endeavour was maintained in order to make them understandable to the learners.

Many films on safety are now available in the U.K. and the U.S.A., and although a number were purchased which were thought to be suitable, they did not give the results expected. Everything shown in them, machines, settings, and language, were totally unlike anything to which the men were accustomed. To overcome their defects as far as the Company was concerned, we set out to make our own films.* These films were very well received, and created considerable interest. They were shown in schools and training centres, and on a number of occasions as shorts in normal cinema shows.

When used in Persia the commentaries are in Persian. As in the case of films, synchrophone screens were designed to be understandable to inexperienced workers and still be of interest to others.

Posters were issued at frequent intervals, as in works in the U.K., but here again they were designed to have a local interest. Persian artists developed the various subjects in their own way, all printing was in Persian, and the posters were produced in the Company's own printing works.

The response to these training aids left the Company in no doubt as to the value of suiting the training to the individual.

STATISTICS

Properly kept statistics issued at regular intervals are the yard-sticks of accident prevention programmes. The number of accidents recorded are reduced to a frequency rate, and the seriousness of the injuries sustained to a severity rate.

Although the ILO have recommended the adoption of a standard method of calculating these rates, it is still the practice for individual countries to use their own methods.

In the U.K. the frequency rate is :

$$\frac{\text{No. of lost time accidents} \times 100{,}000}{\text{No. of man-hours worked}}$$

and the severity rate is :

$$\frac{\text{No. of hours lost} \times 100{,}000}{\text{No. of man-hours worked}}$$

The corresponding rates in the U.S.A. are :
Frequency =

$$\frac{\text{No. of lost time accidents} \times 1{,}000{,}000}{\text{No. of man-hours worked}}$$

and Severity =

$$\frac{\text{Days lost due to accidents} \times 1000}{\text{No. of man-hours worked}}$$

Adjustments to published rates must therefore be made before comparison can be made between the figures of one country and another. Comparison is also made difficult by other factors. In the U.S.A., for instance, the staff employed in a works are included in the returns while in the U.K., only the actual workers are included.

Then there is the vexed question of alternative work. In some quarters it is the practice to give injured persons work of a minor nature while they are incapable of carrying out their normal work. If by this means absence from work is prevented, no accident is recorded.

Another factor which has a bearing on the accident rates is the class of work carried out in a particular works. It is common practice for accident returns to be published under various industrial headings, *e.g.* foundries, engineering shops, etc. In a general way these returns are of interest, but unless the works listed under a particular heading carry out similar operations with similar risks, one will always differ from another in the final results.

Similarly within a particular works, the risk of

* Including "The Wise Man and the Foolish," "Miracle Man," and "Protection Against Chemicals," which were shown at the meeting.

injury in some departments will be greater than in others due to the different types of work carried on with differing risks. On this account the direct comparison of accident rates can give an unfair picture.

As mentioned at the beginning of this paper, the AIOC works included many types of industry. Returns for each department were published monthly, but no great stress was laid on their differing frequency rates. The aim was to establish a reasonable rate for each department, and then set out to better it. This meant a different target figure for each department, but it dispelled any feeling of unfair competition and gave very good results.

Mention was made earlier of the magnitude of the Company's medical department, and the close contact between it and the safety engineer. This close working was responsible for bringing to light an influence on the frequency and severity rates which had not previously been suspected, and has not been considered or even suspected elsewhere.

The fact is that frequency and severity rates are to some extent controlled by the medical attention given to persons injured as the result of accidents. This came to light during the second world war, when the frequency rate suddenly jumped up to more than twice its normal. On making inquiries it was found that owing to the uncertainty of future supplies, replenishment of first-aid boxes in the works had been suspended, and the treatment of first-aid cases transfered to the main dispensary.

The following month the rate again doubled, and the figures were alarmingly high. Fortunately, it was then found possible to restore supplies to the boxes, and the rate immediately fell back to the normal level. After the war, in order to improve the first-aid service a number of dispensaries were established in the works, with the result that another increase in the frequency rate occurred.

The difference between a first-aid case and an accident case is one of degree, and as time passed, the effects of the works dispensaries could be assessed. It was found that the proportion of first-aid cases to accident cases varied in a way which coincided with a change of medical attendant in a dispensary.

These facts, considered together, indicate that the more lenient or humane a doctor is in treating "minor" injuries, the higher will be the frequency rate.

Harsher treatment is not advocated with a view to keeping the frequency rate down, but chiefly to give weight to the following suggestions:

It is, of course, the job of the safety engineer to reduce accidents, in other words his concern is the frequency rate. What happens when a person is injured is outside his control, and on that account he has no influence on the severity rate. Moreover, minor types of injury may have serious and even fatal consequences.

To cite a common example of this, a puncture by an old nail will, as a rule, be quickly forgotten, but on occasions will lead to blood poisoning and may prove fatal.

From the safety engineer's point of view it is therefore just as important to prevent the minor injury as the major accident. To do this effectively he must have some means of assessing the first-aid injuries. At the present time his only yard-stick is the accepted frequency rate, which ignores first-aid cases, and is controlled to some extent by the various factors mentioned above.

The frequency rate must therefore be based on all injuries, whether in the first-aid or accident categories. By doing this, the factors which now influence the present frequency rate will cease to have any effect, and a very much truer picture of the accident position will be gained.

In some quarters doubt will be expressed as to the possibility of obtaining reliable records of first-aid cases, but my company managed to do it satisfactorily, and it could be done elsewhere. The recording of first-aid cases enables my Company to keep exact injury records of the individual employees, and these proved to be of considerable value on many occasions.

ACCIDENTS AND THEIR CAUSES

It is the aim of safety engineers to prevent accidents by taking all possible precautions, and to this end, plants and machines are designed to be free from hazards to the operators. However, in spite of all the precautions which can be taken, the human element and the unforeseen mishap remain, and will continue to cause concern. The human side is largely associated with training, but safeguarding against unforeseen possibilities is a matter which demands constant attention.

To a large extent, the provision of protective equipment for the individual is in this category, as it protects the wearer when other measures fail. In refineries there are many operations which necessitate the wearing of protective equipment as a precautionary measure, and one of the troubles of the safety engineer is to get men to wear what is provided for their protection.

It is, of course, understandable that persons find such equipment irksome to wear, and this is particularly the case in hot climates, where one discards as much clothing as possible. It is up to the safety engineer and those responsible for the purchase of the equipment to endeavour to provide articles which can be worn with the least amount of discomfort.

Appearance as well as comfort plays its part in getting apparel accepted. Some years ago my Company introduced a new type of "Hard Hat," rather like a topee in shape and painted white. It became very popular as a head-dress, so fashionable in fact that platelayers and others who had no real use for them, but who managed to acquire them in some way best known to themselves, used them as ordinary headgear.

However thoroughly precautions are taken to

render machines and processes as safe as possible, and in spite of training and the provision of suitable equipment, accidents resulting from unforeseen circumstances are inevitable. When such an incident occurs and subsequent investigation has established the cause a considerable amount of good can result from the wide publication of the facts. This may be of value in preventing a similar occurrence elsewhere, but is more likely to start trains of thought leading to the solution of other problems.

One such investigation concerns the explosion of drums during repair. Explosions during the use of oxy-acetylene torches are fairly common and as was usual in such cases it was assumed that these were due to oil or gas remaining in the drums after cleaning, and gas-freeing. This theory was disproved when an explosion took place during repair of a new drum which had a leaky seam as it came off the machine.

Another new drum was then tested. The atmosphere inside was thus free from oil or gas, and a torch was used to cut through the end-plate as though it was to be removed from the drum. After cutting for a short period, during which time the torch was used in the normal manner and was not extinguished, samples of the air in the drum were tested, and traces of unburned acetylene were found to be present.

This experiment showed that provided the incision made by a torch is narrow enough, it is possible for unburned acetylene from a lighted torch to pass through and to accumulate inside the drum. This being the case, it is only a matter of time before a sufficient quantity of explosive mixture will be formed. Ignition can then take place from a local hot spot or by passage of the flame through the plate if the incision becomes wider.

The investigation showed that thorough cleaning of a drum before welding is not enough, and it is essential to maintain gas-free conditions during the actual process of welding. One method of doing this is to insert an air pipe in the drum, and thereby maintain a constant change of air within it, thus preventing the build-up of an explosive mixture. No further explosions were experienced in my Company while welding under these conditions.

In another case of a different nature, a serious fire occurred in a 4-gal tin inspection shed. At one end of the shed leakers were repaired by means of heavy soldering bolts which were brought in from a heating stove, situated at a safe distance from the shed.

Investigations established that the fire originated on the floor of the shed at a point where one of the bolts in use was accidently dropped. Following up this pointer a series of experiments were made, heated bolts being dropped or thrown into pools of spirit and on to minor spills on the floor.

It was found that bolts were perfectly safe to be used at soldering heat, and no harm resulted from dropping them provided they were clean and free from scale. If, however, any scale adhered to the surface of the bolt, some particles were dislodged when the bolt struck the floor. These particles overheated on separation from the bolt and occasionally fired vapour in the vicinity.

The safety of the bolt was therefore linked with its freedom from scale, and as the bolts were of necessity heated at a distance from the point of use, thorough cleaning immediately before use was essential. The formation of scale could not be prevented due to the temperature to which the bolts had to be heated and transported before use.

Because of these factors, the employment of this type of soldering bolt was discontinued, and low-voltage electrically heated bolts were substituted for them. Other precautions were taken at the same time to limit the effect of any fire which might occur in the future.

DISCUSSION

D. A. Yonge: Mr MacLean has contrived to give an interesting slant to that dull subject, accident statistics, but I am wondering whether he goes far enough when he says the frequency rate can be made more realistic by taking into consideration first-aid returns. We have all experienced the incident which causes no injury at all—may be an explosion or fire, in which personnel escape injury. Such an event does not affect the frequency rate at all, but surely it is purely chance whether the incident causes no injury or whether it has fatal results, and therefore it might appear that what may be called "incident frequency rate" would be a better guide than the accident frequency rate. If the matter is one purely of chance, then presumably the two will bear a direct relationship. I do not know whether that is so or not, but I would ask whether there is any information to show that there is a direct-relationship between the number of incidents that occur and the number of accidents over a long period.

The second point I would like to raise is in connexion with training. It is stated in the paper that it was found better in Persia to treat safety as a separate subject under the safety engineer, but that may not necessarily be the best means in the U.K. In the case of young chemists, for example, there is a strong body of opinion that safety ought to be incorporated in university training, not necessarily as a separate subject on the curriculum but incorporated in the teaching of the orthodox subjects, so that the young chemist learns his laboratory technique and his safety at the same time. The same might apply to apprentice fitters and other trainee craftsmen. I should be very interested to hear the opinion of other members on that particular point—whether safety should be treated separately or whether it should be an inherent part of ordinary craft training.

The last point which I would like to make concerns the question of drum repairs and Mr MacLean's statement regarding the possibility that acetylene can get into the drum from the welding torch and give rise to an explosive atmosphere. No doubt there are many people who had not realized this possibility. In my Company, we have had no accidents from that cause, possibly because in addition to the ordinary gas-freeing procedure and testing, we use the additional precaution of injecting steam during welding. Steam has the disadvantage that if you use too much you may interfere with the vision of the welder and introduce other hazards in this way, but this can be avoided as long as the quantity of steam is carefully controlled. I would like to know whether there is

any other reason than this for which Mr MacLean prefers air injection during the actual welding process.

T. T. MacLean: In regard to Mr Yonge's first point about the frequency rate and the desirability of relating it to plant accidents or near accidents, briefly the answer is that many incidents or near accidents take place in a works, and it might be months before one finds out that such things occurred. They may be very quickly hidden up. I do not think you could get people to report things like that in time to be of any use. In my Company we recorded all plant accidents as distinct from accidents to personnel, but we never attempted to link possibilities of plant accidents with accidents to men. There are too many unknown quantities about it.

The second point was, I think, on the desirability of using safety engineers or, in other words, specialists, to do the actual training in safety matters. In my Company better results were obtained by using a safety engineer who was an expert in the job. I think that goes for any form of training—if you want to teach chemistry, you employ a chemist to do the work, and safety engineering is such an important matter these days, that it is big enough to justify the use of a specialist in order to obtain the best results.

In regard to the use of steam for preventing explosions during the welding of a drum, I do not see any reason for not using steam, for steam leads to precisely the same result as that achieved with air, that is, it changes the air in the drum and thus prevents the building up of a dangerous atmosphere. Steam possibly has a disadvantage in so far that it may heat up the metal and make it more awkward to handle, and as Mr Yonge has already said, it might interfere with vision. My Company used air, and found it quite useful and satisfactory.

W. R. Davies: I would be very interested to know if Mr MacLean has any views on mechanical handling as a safety measure. To be a little more specific, my Company has had reports from marketing areas which handle packed products to the effect that mechanical handling in some cases has reduced accident frequency by 50 per cent and more, and I was wondering whether he has any figures to show accident frequency before and after Anglo-Iranian installed mechanical gear for handling bitumen drums. In view of events at Abadan, I do not know whether he had time to get any results, but if he did, I would like to know what they were, and also if he could tell us whether there was any appreciable financial saving in lost time payments through the installation of mechanical handling plant.

T. T. MacLean: I am afraid I have to admit that on both those subjects, I have no information. I have been retired for about twelve months, and I am afraid that any figures I might quote would be somewhat out-of-date. Moreover, I cannot say whether mechanical handling gives effective results or not. On the face of it, anything you do to prevent a man handling—regardless of the nature of the goods—tends to prevent accidents. The same thing applies to machine tools; nowadays these are almost completely boxed in to prevent people getting in contact with moving parts. Prevent people from handling acids, chemicals, and such like, and you will cut down the number of accidents. But on the £ *s. d.* side, I am afraid I cannot give you any information.

J. H. G. Carlile: I would like to ask Mr MacLean whether, in the course of training, anything is done to make the workers aware of the hazards of toxic vapours and gases. One can imagine that they are told all about the risks of fire and explosions, but while it may be relatively easy for native workers to appreciate fire risks, it may not be so easy for them to understand the risks associated with breathing petrol vapours or gases, such as H_2S.

Then there is the question of how to deal with technical terms for which the Persian translation would have no real meaning. For example, with electrical hazards, a danger notice carrying the words "High Voltage," whether in English or the Persian equivalent, would probably have no significance for the average native worker.

Mr MacLean has referred to the difficulty of persuading workers to wear protective clothing. In this connexion it may be of interest to mention a case reported some years ago in the U.S.A., where it was desirable for women employees to wear protective hats. Various designs of hats were tried, without much success, until the safety officer allowed an entirely untrue rumour to spread to the effect that the process operated gave off fumes which, while otherwise harmless, had a deleterious effect on waves in the hair, but that the hats supplied were treated with a special chemical which afforded full protection. This subterfuge was entirely successful.

T. T. MacLean: I do not think we made any special point of training, in so far as gas is concerned. The natives had rather a lot of experience of gas and vapour, and knew quite a lot about it before they came to us. Mr Gibson knows of plenty of incidents up in the oilfields, where breaks occurred in the pipelines and gas escaped into the neighbourhood. The natives quickly learned the meaning of gas.

Now in regard to the vocabulary, the Persian language includes remarkably few technical terms, and in consequence a lot of English words are in common use and are well understood. When I left Persia quite a number of new Persian words had been introduced to replace the English ones, but it may be many years before the Persians have a complete technical vocabulary.

The question of designing attractive and protective headgear for women undoubtedly presents the same problems in Persia as in the U.K. and elsewhere.

Dr A. W. Gould: I was very perturbed to hear Mr MacLean say that it is difficult to obtain records of incidents. I realize that some difficulty arises in connexion with a very large undertaking, hardly justifying the word "works" in the English sense. Nevertheless, it means that the safety engineer does not get to know what is going on, and that suggests to me that there is a gap in safety education at a higher level.

There are charge hands, foremen, and superintendents who know what happens in the works, and I suggest that a scheme should be put in hand which enforces them to report incidents to the safety officer. Surely that is the answer.

I rather liked the idea put forward by Mr Yonge that incident rate is more valuable than accident rate, and I think that this information could be collected if safety education were pursued at a slightly higher level.

T. T. MacLean: The recording of every possible source of accident is a big subject. It suggests that every loose nail found on the ground, every time a brick falls off a pile or something slips, all have to be recorded as possible sources of accident, and I do not think that is a physical possibility.

E. J. Sturgess: With regard to native labour, one of the difficulties is to get natives to take the precautions which have been stipulated. In marketing areas the most dangerous operation is undoubtedly the cleaning of tanks which have contained leaded spirit, and the Associated Ethyl Co. Ltd. lay down very detailed precautions which have to be taken when carrying out this operation. It may be that the workers have been accustomed for a number of

years to cleaning tanks which contained unleaded spirit, and they cannot understand the necessity for wearing elaborate protective clothing; this lack of understanding may even extend to the foreman in charge.

In such cases it is very desirable that a man is stationed outside the tank with the responsibility of seeing that the masks and protective clothing are worn. Some oil companies have adopted for use an air-line gas mask, the hood of which can be sealed on to the man. This gives the safety officer an opportunity of checking that the seal is not broken when a man comes out of the tank.

T. T. MacLean: I quite agree with those remarks. My Company was up against the same thing, but tackled it in rather a different way. The cleaner wore a complete suit which was connected to an air-line, but difficulty was experienced in adequately cooling the air. Although various means were tried, including the use of portable compressors, by the time the air reached the man, it was uncomfortably warm. The Company was still working on this problem when I retired, and I do not know of any progress that may have been made since then. However, the aim must be to supply the man with air at a sufficiently low temperature to keep the body and the head cool during the time he is working in the tank.

J. R. Hughes: My Company has adapted the compressed air-line type of breathing apparatus for cleaning out tanks at Kent, and it works very satisfactorily indeed. Where there is no piped air supply, a compressor, filter, and manifold are used for supplying up to six men working inside a tank. Unlike Persia, there is no difficulty in the U.K. in supplying cool air to the respirators.

J. H. Drew: Mr MacLean's paper covers quite a wide sphere of activity in Persia, and I wonder whether figures are available of accidents to wharfingers' personnel and any other personnel employed at Abadan Docks, and if he could give us any information in that respect. There is a very clear risk of accidents occurring to dockside personnel when discharging and/or loading general cargo vessels and mooring and unmooring tankers, and I wondered whether his sphere of activities covered that particular aspect.

T. T. MacLean: That ground was covered, but I am afraid I cannot quote any figures at the present time. Many of the cargo-carrying ships arrived with gangs which had been taken aboard up-river from Funchal, and they did the actual off-loading on to the jetty. My Company's men picked up, loaded into wagons or whatever was necessary, and shifted it away. The incidence of accidents amongst the men was not so very serious compared with other occupations, but my Company was at a disadvantage in this respect, because the men employed on that sort of job were mostly casuals—in other words, they were nearly all "green" all the time. There were not very many of them who were in regular employment and who thereby benefited by experience. Similar men were used for tying up, coupling hoses, and one thing or another, but those men were kept on steady employment and worked according to requirements. Actually, there were not many accidents recorded amongst men employed in either coupling hoses or mooring ships.

The President: First, I would like to comment on Mr MacLean's remarks concerning vapours and gases. He is right in saying that the Persians, who were Company employees, were as much aware of the dangers of petroleum vapours and gases as anyone else at that time. However, no one then realized the very dangerous nature of hydrogen sulphide.

At the beginning of the discussion Mr Yonge said that all persons in an organization should be "safety-minded," and that the ideas of safety should be inculcated at a very early stage in their training. That is a very sound procedure, because everybody is concerned with safety, and although a specialist is employed to train people and to maintain standards, every employee in an organization is responsible, in some degree, for the application of safety methods. It is not just a matter of the safety officer enforcing regulations, but rather (as Mr Yonge suggested) that instruction should be given at an early stage so that it is almost second nature for everyone to look upon every operation from a safety angle, in fact, that such becomes almost automatic.

Safety is a subject in which the Institute is closely interested. The Institute has been busy for some time now, in producing codes of safe practices in the industry for refining, for marketing, and now a Committee is working on a code of safe practice for production. Inquiries have been received from many different authorities regarding safe practice, and the Institute gives all the help it possibly can. It is hoped shortly to form a safety sub-committee where safety officers of the industry can discuss opinions and experiences, and where safety matters can be continuously reviewed, because this subject is of great importance in the petroleum industry.

A vote of thanks was accorded with acclamation.

PHYSICAL CONSTANTS OF A SERIES OF ALKYLNAPHTHALENES AND RELATED NAPHTHENES. ATTEMPTS TO CORRELATE THEIR STRUCTURE WITH PHYSICAL PROPERTIES *

By B. B. ELSNER †

A RANGE of alkylnaphthalenes has been synthesized by Dr J. C. Smith and collaborators in this laboratory; namely, the ten dimethylnaphthalenes,[1, 2] the 1- and 2-methyl, ethyl, *n*-propyl, *n*-butyl, *n*-amyl, and *n*-hexylnaphthalenes,[3, 4] the compounds having odd-numbered side-chains of from 7 to 11 carbon atoms,[5] and the 1- and 2-substituted naphthalenes with side-chains from C_{13} to C_{16}.[6]

At the suggestion of Dr Smith the data on alkylnaphthalenes were supplemented by a further series of compounds with side-chains of even-numbered carbon atoms (*cf* Bannister and Elsner [7]) ranging into the high molecular weight hydrocarbons of lubricating oils, from C_{18} to C_{28}, with the intention of correlating their physical properties with their structure. Attention was given to the influence of the length, the position, and the number of side-chains of the alkylnaphthalenes, the position of the nucleus in the paraffin chain, and of molecular weight on viscosity, on melting and boiling point, refractive index, density, etc.

Considerable advance in the knowledge of the structure of lubricating oils has been gained from the work of Mikeska,[9] and more recently from the extensive systematic investigation outlined in Research Project 42 of the American Petroleum Institute.[10–13]

An approach was made by Hugel [16] to the problem of the composition of lubricating oils by synthesizing pure hydrocarbons of high molecular weight, but the foundation was laid by Mikeska with the preparation of fifty-two hydrocarbons in this range. Most of Mikeska's conclusions were confirmed and the field of research vastly expanded through the synthesis of hydrocarbons of a great variety of molecular types by the team of workers on Project 42.

In the present paper the physical constants of twenty-three hydrocarbons of molecular weight ranging from 240 to 380 are listed in Table I, and an attempt has been made to correlate their structure with their physical properties. In view of the incompleteness of the data and the insufficient number of compounds, the generalizations arrived at are considered to be only tentative.

PREPARATION OF THE HYDROCARBONS

The 1 : 2′-alkylnaphthalenes were prepared by the reduction of the corresponding *n*-alkyl-β-naphthyl ketones obtained by the Friedel–Crafts acylation of naphthalene. The Grignard reaction on some of the suitable ketones, prepared as above, gave finally the 2′-naphthyl alkanes with chains branched on the carbon atom α to the nucleus.

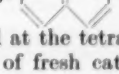
Three methods of synthesis of the *n*-alkyl-1-naphthyl ketones were investigated. The interaction of alkyl cyanides and α-naphthyl magnesium bromide gave the highest yields, increasing as the chain length increased. Catalytic reduction of these ketones yielded the 1 : 1′-naphthylalkanes. 1 : 6-Di-2′-naphthyl hexane was obtained from the diketone prepared by the Friedel–Crafts reaction between tetralin and polymeric adipic anhydride.

2 : 6-Di-*n*-hexylnaphthalene was prepared by the Friedel–Crafts acylation of 2-*n*-hexylnaphthalene and reduction of the 6-*n*-pentyl ketone obtained.

2 : 3-Di-*n*-hexylnaphthalene was obtained from tetralin by the Friedel–Crafts acylation and reduction to 6-*n*-hexyl tetralin. A second hexanoyl group was introduced by the same method into the 7-position. Reduction and dehydrogenation gave the desired hydrocarbon.

1 : 2 : 3-Tri-*n*-butylnaphthalene was obtained by a similar series of reactions to introduce *n*-butyl groups into the 5-, 6-, and 7-positions of tetralin.

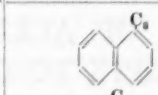
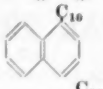
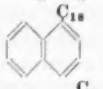
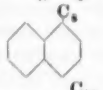
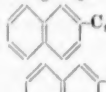
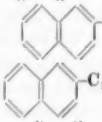
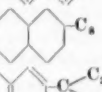
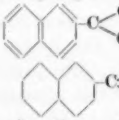
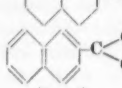
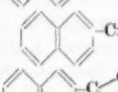
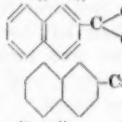
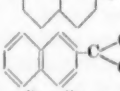
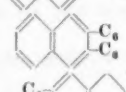
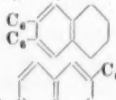
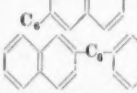
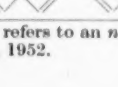
The record of the synthesis of those compounds (*cf* Bannister and Elsner [7]) does not include the preparation of the hydro-aromatic compounds. These compounds were prepared either by catalytic hydrogenation of the corresponding naphthalenes or by selective catalytic reduction of the corresponding naphthyl alkyl ketones in a Baskerville and Lindsay hydrogenator, with 5 to 8 per cent of Raney nickel catalyst, without solvent, under an initial pressure of 120 atm of hydrogen, a temperature of 260° to 270° C, for six hours, and electromagnetic stirring. The autoclave was then left to cool; the next day the hydrogen pressure was increased again to 120 atm at room temperature, and the hydrogenator heated at 260° C for four hours.

It was found that the hydrogenation proceeded to the decalyl(decahydronaphthyl) stage if the starting material was an alkyl naphthalene; if, however, the corresponding alkyl ketones (*e.g.* ) was used the reduction stopped at the tetralyl stage. Addition of the same amount of fresh catalyst and hydrogenation for a further six hours, under the same

* MS received 5 February 1954.

† The Dyson Perrins Laboratory, Oxford.

TABLE I (*a*)

No.	Hydrocarbon	Structure †	Empirical formula	Theoret. mol. wt.	Kinematic viscosity, cs at temp.: 0° C	20° C	100° F	210° F
1	1 : 1′-Naphthyloctane		$C_{18}H_{24}$	240	49·6	16·95	7·97	2·10
2	1 : 1′-Naphthyldecane		$C_{20}H_{28}$	268	—	20·94	10·50	2·51
3	1 : 1′-Naphthyldodecane		$C_{22}H_{32}$	296	—	—	13·66	3·11
4	1 : 1′-Naphthyloctadecane		$C_{28}H_{44}$	380	—	7·27 at 80° C	27·7 *	4·97
5	1 : 1′-Tetralyloctane		$C_{18}H_{26}$	244	123·7 at 0·3° C	37·8	16·8	3·23
6	1 : 1′-Decalyloctane		$C_{18}H_{34}$	250	35·5	13·26	7·41	2·13
7	1 : 1′-Decalyldodecane		$C_{22}H_{42}$	306	—	27·7	13·92	3·34
8	1 : 2′-Naphthyloctane		$C_{18}H_{24}$	240	—	11·17	6·27	1·88
9	1 : 2′-Naphthyldecane		$C_{20}H_{28}$	268	—	—	8·29 ‡	2·31 ‡
10	1 : 2′-Naphthyldodecane		$C_{22}H_{32}$	296	—	—	11·0 ‡	2·83 ‡
11	1 : 2′-Naphthyloctadecane		$C_{28}H_{44}$	380	—	6·74 at 80° C	22·5 *	4·54
12	1 : 2′-Decalyloctane		$C_{18}H_{34}$	250	36·1	14·34	8·10	2·12
13	3 : 2′-Naphthyloctane		$C_{18}H_{24}$	240	81·0	19·66	9·18	2·02
14	3 : 2′-Decalyloctane		$C_{18}H_{34}$	250	69·1	23·2	11·8 *	2·8 *
15	4 : 2′-Naphthyloctane		$C_{18}H_{24}$	240	110·0	29·0	12·5 *	2·4 *
16	4 : 2′-Naphthyldecane		$C_{20}H_{28}$	268	144·5 at 0·5° C	37·6	15·16	2·68
17	4 : 2′-Naphthyldodecane		$C_{22}H_{32}$	296	167·5	46·0	18·29	3·19
18	4 : 2′-Decalyldodecane		$C_{22}H_{42}$	306	163·5	46·3	17·52	3·35
19	6 : 2′-Naphthyldodecane		$C_{22}H_{32}$	296	215	57·2	21·2	3·46
20	2 : 3-Di-*n*-hexylnaphthalene		$C_{22}H_{32}$	296	—	35·9	16·11	3·07
21	6 : 7-Di-*n*-hexyl-1 : 2 : 3 : 4-tetrahydronaphthalene		$C_{22}H_{36}$	300	65·4 at 0·5° C	20·9	10·06	2·34
22	2 : 6-Di-*n*-hexylnaphthalene		$C_{22}H_{32}$	296	—	—	12·91	3·05
23	1 : 6-Di-2′-naphthylhexane		$C_{26}H_{26}$	338	—	—	—	—

* Extrapolated. † C_6, C_{10}, etc., refers to an *n*-paraffinic hydrocarbon chain with the number of C atoms indicated.
‡ Dr Stofberg's thesis, Amsterdam, 1952.

TABLE I (*b*)

No.	Kinematic viscosity, cs at temp. :		Calculated Saybolt visc		Kinematic visc index	Melting point, ° C	Boiling point, ° C at mm Hg		Density at 32° F *
	160° C	240° C	100° F	210° F			10	1	
1	—	—	51·9	33·2	56	0·6	—	170/4 mm	0·9561
2	1·186	—	60·6	34·6	61	15·6	—	200/4 mm	0·9462
3	—	—	72·1	36·9	94	28·3	—	209/4 mm	—
4	2·07	—	131·0	42·5	110	53·1	—	170/0·5 mm	0·8840 at 55° C
5	—	—	84·3	37·0	42	No cryst.	189	151/0·9 mm	0·9293
6	1·06	0·58	50·0	33·3	94	—	182	149	0·8850
7	1·52	0·79	73·1	37·4	127	—	227	192	0·8828
8	0·97	—	46·4	32·4	85	10·9	—	156	0·9480
9	—	—	53·0	34·0	101	22·5	—	—	0·9388
10	—	—	62·6	35·7	116	32·0	—	—	—
11	2·0	—	108·2 *	41·1	133	54·3	—	—	—
12	1·14	0·60	52·3	33·2	56	—	184	150	0·8816
13	0·93	0·49	56·0	32·9	−38	No cryst.	182	156	0·9541
14	—	—	65·1	35·6	85	—	172	138/0·7 mm	0·8924
15	—	—	67·7	34·3	−51	No cryst.	181	116/0·3 mm	0·9518
16	1·17	0·57	77·8	35·2	−55	No cryst.	201	150	0·9401
17	—	—	90·4	36·9	−4	−5·5	224	183	0·9322
18	—	—	87·2	37·4	49	—	215	173	0·8803
19	—	—	102·6	37·8	−8	No cryst.	219	241/2 mm	0·9320
20	1·33	0·66	81·6	36·3	22	9·8	229	202/4 mm	0·9364
21	1·09	0·57	58·0	34·0	32	5·9	—	191/4 mm	0·9196
22	1·40	0·74	69·3	36·3	103	36·2	—	—	—
23	—	—	—	—	—	101·6	—	—	—

* Extrapolated.

TABLE I (*c*)

No.	Density at :				Refractive index at 20° C			Dispersion at 20° C $(n_F - n_C)10^4$
	68° F	100° F	70·4° C	210° F *	n_D	n_F	n_C	
1	0·9426	0·9302	0·9078	0·8881	1·55275	1·56749	1·54713	203·6
2	0·9320	0·9197	0·8997 at 66·2° C	0·8771	1·54344	1·55718	1·53820	189·8
3	0·9222 *	0·9103	0·8886	0·8695	1·53470 *	1·54757	1·52987 *	177·0 *
4	0·9064 *	—	0·8741	0·855	1·5235 *	1·51915	1·50409	150·6 at 55° C
5	0·9157	0·9037	0·8842 at 66·3° C	0·8623	1·51142	1·52033	1·50786	124·7
6	0·8720	0·8602	0·8389	0·8202	1·47617	1·48205	1·47371	84·4
7	0·8704	0·8589	0·8409 at 66·3° C	0·8200	1·47694	1·48291	1·47450	84·1
8	0·9345	0·9220	0·8997	0·8800	1·55095	1·56557	1·54529	202·8
9	0·9253	0·9131	0·8910	0·8716	1·54197	1·55568	1·53681	188·7
10	0·9182 *	0·9063 *	0·8842	0·8648	1·53543 *	1·54810	1·53030 *	178·0 *
11	0·9036 *	0·8766 at 60·3° C	0·8699	0·851	1·5235 *	1·51904	1·50386	172·5 * / 151·8 at 55° C
12	0·8685	0·8567	0·8382 at 66·2° C	0·8170	1·47487	1·48081	1·47240	84·1
13	0·9405	0·9280	0·9054	0·8857	1·55752	1·57283	1·55158	212·5
14	0·8790	0·8672	0·8483 at 66·3° C	0·8267	1·47941	1·48539	1·47692	84·7
15	0·9381	0·9256	0·9060 at 66·3° C	0·8837	1·55437	1·56942	1·54867	207·5
16	0·9267	0·9147	0·8950 at 66·4° C	0·8729	1·54474	1·55870	1·53941	192·9
17	0·9187	0·9070	0·8877 at 66·7° C	0·8661	1·53729	1·55048	1·53225	182·3
18	0·8675	0·8561	·8375 at 66·6° C	0·8168	1·47594	1·48190	1·47348	84·2
19	0·9188	0·9067	0·8875 at 66·3° C	0·8654	1·53851	1·55186	1·53341	184·2
20	0·9231	0·9109	0·8917 at 66·4° C	0·8700	1·54305	1·55677	1·53783	189·4
21	0·9052	0·8933	0·8734 at 66·2° C	0·8508	1·50849	1·51743	1·50492	125·1
22	0·9168 *	0·9051	0·8833	0·8647	1·54170 *	—	—	192·4
23	—	—	—	—	—	—	—	—

* Extrapolated.

TABLE I (*d*)

No.	Specific dispersion at 20° C $\frac{n_F - n_C}{d} \times 10^4$	Specific refraction at 20° C $\frac{n^2 - 1}{n^2 + 2} \cdot \frac{1}{d}$	Molecular refraction $\frac{n^2 - 1}{n^2 + 2} \cdot \frac{M}{d}$		Molecular vol	
			Found	Calc	Found	Calc
1	216·0	0·3394	81·5	78·6	254·6	—
2	203·6	0·3384	90·7	87·8	287·5	—
3	191·9	0·3374	99·8	97·1	321·0	—
4	170·4	0·3375	128·3	124·8	419·2	—
5	136·2	0·3274	79·9	79·5	266·4	265·7
6	95·6	0·3236	80·9	80·9	286·6	286·1
7	96·6	0·3246	99·3	99·3	351·5	351·3
8	217·0	0·3414	81·9	78·6	256·8	—
9	203·9	0·3401	91·1	87·8	289·6	—
10	193·9	0·3393	100·4	97·1	322·3	—
11	173·5	0·3388	128·7	124·8	420·4	—
12	96·8	0·3241	81·0	80·9	287·8	286·1
13	225·9	0·3425	82·2	78·6	255·1	—
14	96·4	0·3228	80·7	80·9	284·4	286·1
15	221·2	0·3418	82·0	78·6	255·8	—
16	208·2	0·3410	91·4	87·8	289·1	—
17	198·4	0·3401	100·7	97·1	322·1	—
18	97·1	0·3251	99·5	99·3	352·7	351·3
19	200·8	0·3407	100·8	97·1	322·1	—
20	205·2	0·3415	101·0	97·1	320·6	—
21	138·2	0·3296	98·9	98·0	331·4	330·9
22	209·9	0·3431	101·5	97·1	322·7	—
23	—	—	—	—	—	—

conditions, resulted in complete saturation. The product was filtered, washed three times with water, dried over sodium sulphate, and distilled from sodium under reduced pressure through a 15-cm Vigreux column.

It is well known that four hydrogen atoms can be added to the naphthalene nucleus without the second ring being reduced although, under the drastic conditions used in this case, the reduction of only one ring of the ketone was not expected. It seems therefore that the conjugated system extended by the carbonyl group ensures selective hydrogenation of the ring bearing the side-chain, the formation of water probably deactivating the catalyst so that no further reduction can occur unless the catalyst is renewed.

Oxidation of the tetralins with dilute nitric acid in a sealed tube at 190° to 200° C gave phthalic acid, thus indicating that the side chain is positioned on the reduced ring.

The infra-red absorption spectra of the tetralyl compounds obtained by the catalytic hydrogenation of the ketones (measured by Dr F. B. Strauss, the Dyson Perrins Laboratory) shows the characteristic band at 12·98 μ of an ortho-disubstituted benzene ring, which proves that the side-chain is located on the hydrogenated part of the tetralin (Formula I).

(I)

(II)

By comparison, in the spectra of the 6 : 7-di-*n*-hexyl-1 : 2 : 3 : 4-tetrahydronaphthalene the above-mentioned band is absent while a new band appears at 11·55 μ. The latter indicates the absence of adjacent hydrogens in a benzene ring, which occurs in a 5 : 7- or 6 : 7-substituted tetralin. Therefore the two substituents can be located only in the benzene part of the tetralin (Formula II).

PURIFICATION OF THE HYDROCARBONS

The purity (Table II) of the hydrocarbons which could be obtained crystalline was determined by taking their melting curves by the method described

TABLE II

Substance	Mol % impurity	Melting range °C
1-(1′-Naphthyl)-*n*-octane	2·6	0·9
1-(1′-Naphthyl)-*n*-decane	5·4	1·2
1-(1′-Naphthyl)-*n*-dodecane	1·8	0·6
1-(1′-Naphthyl)-*n*-octadecane	2·0	0·7
1-(2′-Naphthyl)-*n*-octane	0·8	0·9
1-(2′-Naphthyl)-*n*-decane	0·8	0·6
1-(2′-Naphthyl)-*n*-dodecane	1·0	0·85
1-(2′-Naphthyl)-*n*-octadecane	6·0	1·2
4-(2′-Naphthyl)-*n*-dodecane	—	4·9
2 : 6-Di-*n*-hexylnaphthalene	0·3	0·3
2 : 3-Di-*n*-hexylnaphthalene	—	3·2
6 : 7-Di-*n*-hexyl-1 : 2 : 3 : 4-tetrahydronaphthalene	—	4·6
1 : 6-Di-2′-naphthylhexane	1·6	1·0

by Smit.[8] Purity determinations were not carried out on the decalyl compounds, as these were probably mixtures of stereo-isomers.

Those compounds which, on the evidence of their melting curves, were considered not pure enough for accurate measurements, and the hydro-aromatic and

branched-chain compounds, were distilled through a Vigreux type column, 1 metre long, and the best fraction percolated through alumina. The alumina–oil ratio was about 25, and pentane was used as a developer. In some cases chloroform–methanol was used in order to recover the total sample.

DETERMINATION OF PHYSICAL CONSTANTS

The following were determined :

Kinematic Viscosity at 0°, 20° C, 100° F, 160° C, 210° F, and 240° C, or as indicated. With two exceptions, all the measurements were carried out in the falling needle viscometer, giving dynamic viscosities, from which, with the interpolated or extrapolated densities, kinematic viscosities were calculated. 1 : 2′-Naphthyloctane and 6 : 7-di-*n*-hexyl-1 : 2 : 3 : 4-tetrahydronaphthalene were measured in a modified BSA-type viscometer.

Kinematic Viscosity Indices were calculated by the Dean and Davis principle using the standard method IP 73/53 of calculating viscosity index.

Melting Points were taken from the melting curves, and are correct within ±0·1° C.

Boiling Points at 10 mm are taken from the distillation graphs, and are correct to ±1° C. The boiling points taken at incidental pressures *in vacuo* are insufficiently accurate, and in any case do not allow comparison.

Densities at 68° F, 100° F, 70·4° C, or as indicated, were measured in a 2-ml plug type pycnometer. Densities at 32° F and 210° F were extrapolated. The accuracy of the measurement is about 5×10^{-4}.

Refractive Indices at 20° C were measured on the Bausch and Lomb refractometer, and are accurate to $\pm 3 \times 10^{-5}$. The compounds melting above 20° C were measured at higher temperatures and the values at 20° C obtained by extrapolation.

Dispersions $(n_F^{20} - n_C^{20}) \times 10^4$ were measured on the Bausch and Lomb refractometer and are correct to $3\sqrt{2} \times 10^{-5}$.

Specific Dispersions were calculated according to the formula : $(n_F^{20} - n_C^{20})/d_{20} \times 10^4$.

Specific Refractions were obtained according to the Lorentz–Lorenz formula : $(n^2 - 1)/(n^2 + 1) \times 1/d$ (at 20° C).

Molecular Refractions were obtained according to the equation : $(n^2 - 1)/(n^2 + 1) \times M/d$; where $n = n_D^{20}$; $d = d_4^{20}$; M = molecular weight.

The calculated values for the molecule were obtained as the sum of atomic refractions from Eisenlohr's [19] well-known atomic data, on the basis of the structural formulæ.

Molecular Volumes. Experimental values were obtained from the molecular weight divided by density at 20°, and the calculated values from the equation of Kurtz and Lipkin [20] on the basis of atomic values for saturated hydrocarbons.

$$V = 16{\cdot}29n_1 + 13{\cdot}15n_2 + 9{\cdot}7n_3 + 31{\cdot}2 \text{ cc/gram mol at } 20^\circ \text{ C}$$

where n_1 = number of chain C atoms;
n_2 = numbers of ring C atoms;
n_3 = number of ring junction C atoms;
31·2 = residual volume constant.

INFLUENCE OF STRUCTURE ON PHYSICAL PROPERTIES

Viscosity

The kinematic viscosities of 1 : 1′-naphthylalkanes have higher values compared with the corresponding members of the 1 : 2′-naphthylalkanes. The former

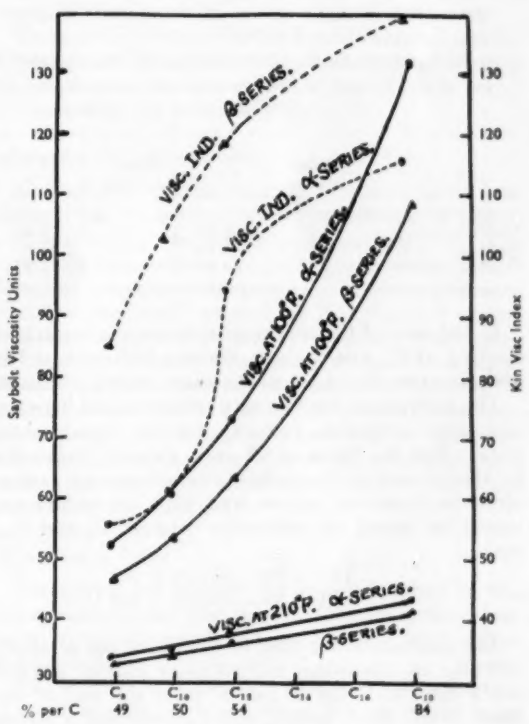


FIG 1

INFLUENCE OF LENGTH OF SIDE-CHAIN ON VISCOSITY AND VISCOSITY INDEX

show, however, larger temperature coefficients and have therefore lower viscosity indices (Fig 1).

With increasing length of the *n*-paraffin side-chain, the kinematic viscosity as well as the viscosity index, increase. The increase in molecular weight is, however, a second variable which has also to be taken into consideration.

The *increment* of viscosity per additional carbon atom in both series of *n*-alkylnaphthalenes increases with the length of the side-chain.

Schiessler *et al* [12] found that aromatics and naphthenes (M.W. range of 340 to 480) have a higher

viscosity increment than *iso*paraffins (of the same range) for a given increase in molecular weight through additional paraffinic carbon atoms. They found for their aromatics and naphthenes a viscosity increment of about 1·6 cs per carbon atom against 1·1 for the *iso*-paraffins. They consider the supporting evidence for the former was not conclusive, since it would mean that the viscosity (at 100° F) of a monocyclic or hydro-aromatic hydrocarbon would increase more than that of an *iso*paraffin: they expected the reverse result, because with increasing molecular weight the proportion of paraffin increases and should approach more closely the properties of an *iso*paraffin. The values listed in Table III support their figures and not their expectation.

TABLE III

Viscosity Increment for Each Added C-atom in Chain at 100° *F*

	α-Series		β-Series	
	Centi-stokes	Saybolt Uni-versal	Centi-stokes	Saybolt Uni-versal
C_8–C_{10} . .	1·27	4·35	1·01	3·3
C_{10}–C_{12} . .	1·58	5·75	1·35	4·8
C_{12}–C_{14} . .	2·46	10·30	1·91	7·6

In the case of the alkylnaphthalenes the increment starting at C_8 side-chain is already higher than 1·1, and increases above 1·6 as the chain length increases.

The increments for viscosity index quoted here are somewhat irregular, perhaps due to experimental error. But the figure of 5·3 units given by Schiessler for the increase in kinematic viscosity index per carbon atom for aromatics agrees well with the values obtained by taking the difference between C_8 and C_{18}, viz:

$$110 - 56 = 5/410 = 5{\cdot}4$$
$$135 - 85 = 50/10 = 5{\cdot}0$$

The position of the ring in the chain has a strong influence on viscosities and viscosity indices. When the 2′-naphthyl ring is moved from the end of the chain to the third, fourth, and sixth carbon, a strong increase in viscosity (except at the highest temperatures) and a very marked decrease in viscosity index results (Fig 2).

These findings are in accordance with the work of Schiessler *et al*,[11,12] who state that the shift of a phenyl or *cyclo*hexyl ring from the end of a paraffin chain to the centre decreases the viscosity by as much as 45 per cent, and with the work of Cosby and Sutherland,[10] who found that the position of a substituent chain of an *iso*paraffin, influences the viscosity and probably the viscosity index in a similar way. These workers, too, are not in agreement with the tentative conclusion of Mikeska,[9] that the location of the nucleus has a small effect on viscosity and viscosity index.

Comparing 1 : 2′-naphthyldodecane with 2 : 3-di-*n*-hexyl- and 2 : 6-di-*n*-hexylnaphthalene, it appears that, in the temperature range considered, the last two compounds have the higher kinematic viscosities and the lower viscosity indices, whilst the viscosity index strongly depends on the place of the two side-chains. The replacement of one alkyl side-chain by two in this case, each being half its length, decreases the viscosity index. These findings agree with the conclusions of Mikeska,[9] on the effect on viscosity index of replacing one side-chain by two or more

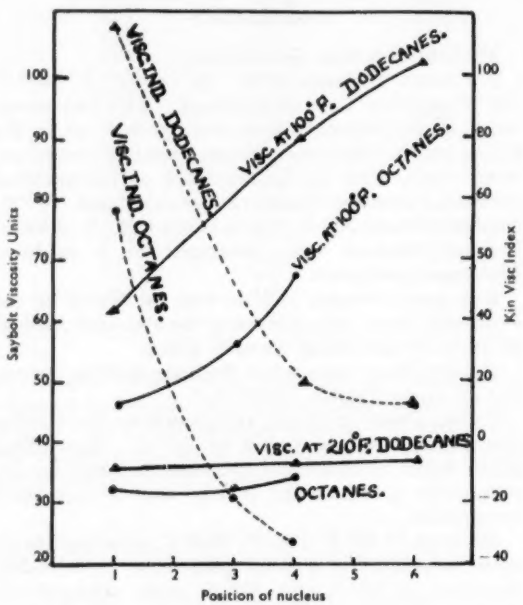


FIG 2

EFFECT OF POSITION OF NAPHTHALENE RING IN THE CHAIN ON VISCOSITY AND VISCOSITY INDEX

shorter chains of a corresponding number of carbon atoms.

Comparing also the viscosity indices of the above compounds with those of 4 : 2′- and 6 : 2′-naphthyldodecanes which have the lowest viscosity index, and keeping in mind that among the most important factors governing the viscosity index is the shape of the molecule, it becomes clear that the two above-mentioned conclusions of Mikeska regarding viscosity and viscosity index contradict themselves.

The effect of complete saturation of the nucleus on viscosities is indeterminate and very small in these series, causing mainly a slight increase.

Refractive Index

By plotting the refractive indices of both series against the number of C-atoms in the chain, two smooth curves are obtained which gradually approach and merge at C_{18} (Fig 3). Data not taken from Table I are taken from reference 6.

With the lengthening of the paraffin side-chain the

refractive index decreases rapidly, as expected, but with decreasing decrements.

The refractive indices of the β-substituted naphthalenes are lower than those of the corresponding α-isomers, and the decrements, with increasing chain length, are smaller.

On saturating the naphthalene ring the decrease in density accompanied by the loss of exaltation of the aromatic double bonds causes the usual enormous reduction in refractive index.

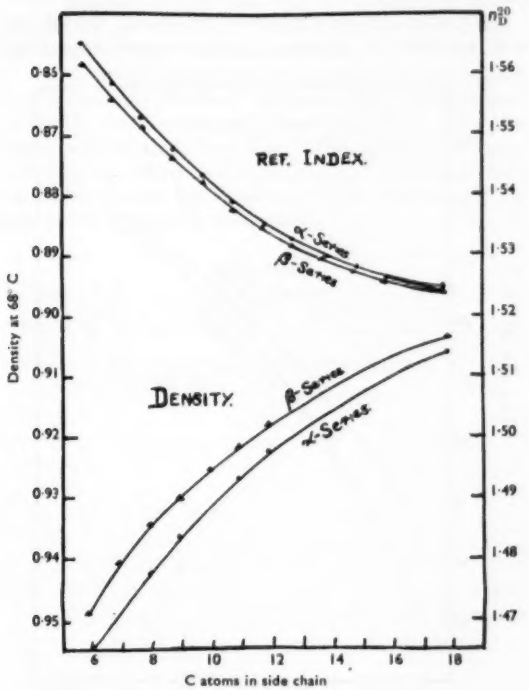


FIG 3

EFFECT ON DENSITY AND REFRACTIVE INDEX

Although the data on homologues of the decalin series is scanty, it can be said that the effect of lengthening the side-chain is very small (Table IV).

TABLE IV

	n_D^{20}	d_4^{20}	Specific Dispersion $(n_F - n_C)/d_4^{20} \times 10^4$
1-(1′-Naphthyl)-octane	1·5527	0·9426	—
1-(2′-Naphthyl)-octane	1·5509	0·9345	—
1-(1′-Decalyl)-octane	1·4761	0·8720	95·6
1-(2′-Decalyl)-octane	1·4748	0·8685	96·8
3-(2′-Decalyl)-octane	1·4794	0·8790	96·4
1-(1′-Decalyl)-dodecane	1·4769	0·8704	96·6
4-(2′-Decalyl)-dodecane	1·4759	0·8675	97·1

Smittenberg and Mulder [14] derived a simple formula for the relation between the refractive index and the number of carbon atoms or molecular weight for some homologous series of hydrocarbons. No formulæ, however, are given for homologues of naphthalene or decalin.

In a survey of Smittenberg and Mulder's work, van Nes and van Westen [15] pointed out that a rough estimate of the refractive index of higher members can be made by plotting the data of a few members against the reciprocal molecular weight and drawing the best straight line through these points and n_∞ and M_∞. The line for alkyl decalins shows no change of refractive index and confirms the above findings.

Specific Dispersion

Because the paraffins have a much lower specific dispersion than the naphthalenes, the increase in length of the side-chain causes a greater reduction.

There is very little difference in the values of specific dispersion of saturated cyclic homologues, obtained by lengthening the side-chains, a fact which is useful in controlling the saturation (Table IV).

Molecular Refraction

Molecular refraction, relating refractive index and density, has been found useful as a check of purity and identity of saturated compounds.[11,12,18] The experimental values for the naphthenes (alkyl decalins) included in this paper are in good agreement with the calculated values, from Eisenlohr's [19] atomic data, on the basis of structural formulæ. The figures for the tetralins show some discrepancies which are of the same order as those found for the alkyl benzenes by Schiessler *et al.*[11, 12, 13] Greater discrepancies between experimental and calculated values occur with the alkyl naphthalenes (4 per cent on the average) which reflects the increased exaltation effect of condensed aromatic nuclei (Table I).

Molecular Volume

The agreement between the observed values for the decalyl compounds and the values calculated according to the equation of Kurtz and Lipkin [20] for paraffins and naphthenes is fairly good.

The increase in molecular volume on hydrogenation of one double bond, which these authors found to be 6·8 cc on the average, give values in good agreement for the volume change from the tetrahydronaphthalenes to the corresponding decalins.

The calculated figures for the volume change from the naphthalenes to the corresponding decalins, however, are not in such good agreement.

The experimental values of molecular volume of the isomeric alkyl naphthalenes fall close together, especially where isomerization is due to the position of the nucleus in the paraffin chain, thus indicating that their densities are very similar (Table V). A definite trend exists, however, between the α and β series, which is discussed below under densities. The increase of molecular volume with chain length is fairly constant for two additional CH_2 being approximately 33 cc/mol (Table I).

TABLE V

	Mol. vol.	Density at 20°	M.p., °C
1-(2′-Naphthyl)-*n*-octane .	256·8	0·9345	10·9
3-(2′-Naphthyl)-*n*-octane .	255·1	0·9405	No cryst.
4-(2′-Naphthyl)-*n*-octane .	255·8	0·9381	No cryst.
1-(2′-Naphthyl)-*n*-decane .	289·6	0·9253	22·5
4-(2′-Naphthyl)-*n*-decane .	289·1	0·9267	No cryst.
1-(2′-Naphthyl)-*n*-dodecane	322·3	0·9182	32·0
4-(2′-Naphthyl)-*n*-dodecane	322·1	0·9187	−5·5
6-(2′-Naphthyl)-*n*-dodecane	322·1	0·9188	No cryst.

Densities

As with the refractive index the densities of the 2-substituted alkylnaphthalenes have lower values than the 1-substituted isomerides. Here, too, this statement of Smith *et al*[5, 6] is confirmed for the densities measured over the range of temperatures mentioned above (Fig 3).

Furthermore, with increasing length of the aliphatic chain the densities decrease progressively more slowly, because the values produced by the change from aromatic to aliphatic character are influenced by a second variable, namely the increasing density caused by the higher molecular weight of the lengthened paraffinic part. The decrements in the 2-series are smaller than in the 1-series.

As already pointed out under molecular volume, hydrogenation of the naphthalene ring causes a considerable fall in density. Reduction of the tetralin compound (3 double bonds) lowers the density more than the reduction of the first stage from naphthalene to tetralin nucleus (2 double bonds). The position of the decalin ring in the chain has only a small influence on density (Table IV).

Melting Points

The influence of the ratio of aliphatic to aromatic carbon atoms of *n*-alkylnaphthalenes on melting points has been discussed by Smith *et al*.[5, 6]

According to these workers, the aliphatic character asserts itself after the initial fall from naphthalene, with small variations up to hexylnaphthalene. Then the two series show rising melting points which plotted against the number of carbon atoms in the side-chain produce mildly zig-zag curves which cross and recross.

Further purification of the alkylnaphthalenes prepared by Bannister and Elsner gave melting points slightly differing from the values reported before. These melting points plotted against C-atoms in the side-chain give smooth curves from C_6 for both series, with decreasing increments as the chain length increases (Fig 4). Densities and refractive indices produce also smooth curves when plotted against the number of C-atoms in the side-chain.

The rule that the 2-substituted naphthalenes have higher melting points than the 1-isomers does not cease to hold above *n*-decylnaphthalene,[6] as the curves do not cross but only converge with increasing chain length.

Three members of the 2-isomers (*cf* Smith *et al*[6]) show melting points which are lower than the curve suggests (Fig 4, points marked x). This may be due to a complicating factor as observed in at least one case, where the time–temperature curve of a melting hydrocarbon has indicated the presence of a second crystalline form. There is a possibility that, where the m.p.–C curve of these 2-naphthylalkanes would give a curve of a zig-zag nature, neighbouring hydrocarbons (odd or even) are not in the same crystalline form.[21, 22]

The rise in melting point in the series having an even number of aliphatic carbon atoms beginning

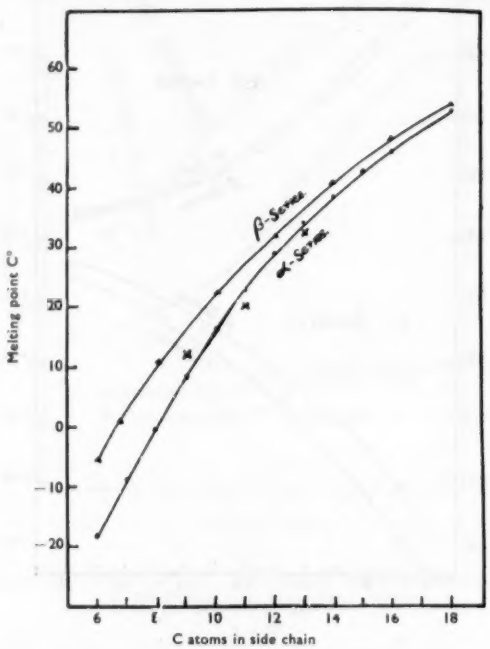


FIG 4

CHANGE OF MELTING POINT WITH LENGTH OF CHAIN

with octane is almost equal to the corresponding increment in the series with an odd number beginning with 9 carbon atoms. This applies very well to the 1-series and would be in agreement in the 2-series, the melting points being taken from the smooth curve.

Although interpretation of the melting point data is difficult, as some hydrocarbons could not be crystallized, it seems that the melting point decreases rapidly as the naphthalene ring moves towards the middle of the chain (Table V). The fall in melting point is also apparent on replacing a single side-chain by two or more substituent chains, the total number of carbon atoms remaining constant.

1 : 2′-naphthyl-*n*-dodecane, m.p. 32° C.
2 : 3-di-*n*-hexylnaphthalene, m.p. 9·8° C.
1 : 2 : 3-tri-*n*-butylnaphthalene, liquid, no cryst.

The relatively high m.p. (36·2° C) of the ββ′-isomer, 2 : 6-di-*n*-hexylnaphthalene is probably due to the molecular symmetry. This has been pointed out in the case of the dimethylnaphthalenes (Smith *et al* [1]), where the 2 : 6-dimethylnaphthalene has the highest melting point. The 2 : 6-dialkyl compounds are obviously the most symmetrical disubstituted naphthalenes.

ACKNOWLEDGMENTS

The author thanks Sir Robert Robinson, O.M., F.R.S., for his interest in this work, and the Anglo-Iranian Oil Co. for financial support.

The purifications and measurements were carried out in the Koninklijke-Shell Laboratorium, Amsterdam, by Mr H. van Kranen and Miss C. G. Kool under the supervision of Dr K. van Nes. The author gratefully acknowledges their collaboration and helpful discussion, and thanks the directors of the laboratory for permission to publish these data.

References

[1] Bailey, A. S., Bryant, K. C., Hancock, R. A., Morell, S. H., and Smith, J. C. *J. Inst. Petrol.*, 1947, **33**, 503.
[2] Evans, R. F., and Smith, J. C. *J. Inst. Petrol.*, 1951, **37**, 80.
[3] Morell, S. H., Pickering, G. B., and Smith, J. C. *J. Inst. Petrol.*, 1948, **34**, 677.
[4] Bailey, A. S., Pickering, G. B., and Smith, J. C. *J. Inst. Petrol.*, 1949, **35**, 103.
[5] Anderson, D. G., and Smith, J. C. *J. Inst. Petrol.*, 1952, **38**, 415.
[6] Anderson, D. G., Smith, J. C., and (in part) Rallings, R. J. *J. chem. Soc.*, 1953, 443.
[7] Bannister, B., and Elsner, B. B. *J. chem. Soc.*, 1951, 1055.
[8] Smit, W. M. Thesis 1946, Vrije Universiteit, Amsterdam.
[9] Mikeska, L. A. *Industr. Engng Chem.*, 1936, **28**, 970.
[10] Cosby, J. N., and Sutherland, L. H. *Proc. A.P.I.* 1941, **22** [III], 13.
[11] Schiessler, R. W., Cosby, J. N., Clark, D. G., Rowland, C. S., Sloatman, W. S., and Herr, C. H. *Proc. A.P.I.* 1942, **23**, [III], 15.
[12] Schiessler, R. W., Cosby, J. N., Clark, D. G., Rowland, C. S., Sloatman, W. S., and Herr, C. H. *Proc. A.P.I.* 1943, **24** [III], 49.
[13] Schiessler, R. W., Herr, C. H., Rytina, A. W., Weisel, C. A., Fischl, F., McLaughlin, R. L., and Kuehner, H. H. *A.P.I.*, 1947, **28** (III), 42.
[14] Smittenberg, J., and Mulder, D. *Rec. Trav. Chim.* 1948, **67**, 813, 826.
[15] van Nes, and van Westen. "Aspects of the constitution of Mineral Oils," p. 84. London: Elsevier Publ. Co., 1951.
[16] Hugel, G. *Chim. et Industr.*, 1932, **26**, 1282.
[17] Pickering, G. B., and Smith, J. C. *Rec. Trav. chim. Pays-Bas*, 1950, **69**, 535.
[18] Vlugter, J. C., Waterman, H. I., and van Westen, H. A. *J. Inst. Petrol. Tech.*, 1935, **21**, 661, 701.
[19] Eisenlohr, F. *Z. Phys. Chem.*, 1910, **75**, 600.
[20] Kurtz, S. S., and Lipkin, M. R. *Industr. Engng Chem.*, 1941, **33**, 779.
[21] Smith, J. C. *Ann. Repts Chem. Soc.*, 1938, **35**, 259.
[22] Piper, S. H., Chibnal, A. C., Hopkins, S. J., Pollard, A., Smith, J. A. B., and Williams, E. F. *Biochem. J.*, 1931, **25**, 2072.

A RAPID METHOD FOR DETERMINING THE CHAR VALUE OF KEROSINE *

By A. R. JAVES † (FELLOW) and MISS C. LIDDELL †

SUMMARY

The time which must elapse before char value results by the IP test procedure become available is inconvenient for refinery control purposes, and may result in delaying tank movements, shipments, and so on. A method therefore has long been sought whereby results could be obtained within a shift period or during a normal working day.

A method has now been developed by which the char value of a kerosine can be determined in an overall time of eight hours with an accuracy closely approaching that of the IP method. This method entails the distillation of the sample to a 7 per cent residue under a nitrogen blanket and the burning of this residue in a modified form of the IP lamp.

PRELIMINARY WORK

CHAR value tests by the IP method 10 require an elapsed time of about 27 hours for their completion. This delay has always been inconvenient for refinery control purposes, and a method has therefore been sought which could be carried out in a few hours and give results in good agreement with those of the IP tests. Mere shortening of the burning time in the normal IP test is of no value, because the amount of char formed is not a linear function of the length of test and the weight of char obtained by a four or five hour burning test is of the order of only a milligram from a high char kerosine.

A number of widely differing methods were tried, some of which showed no correlation whatsoever with the char value, while others, after showing preliminary promise, failed on further investigation. A glass wool wick used in a small lamp of a type previously used for sulphur determinations showed a variation in the amount of darkening of the wick which took place with different samples, but measurement of the length of wick blackened by a series of kerosines gave results that were too erratic to be of any use. Unsuccessful attempts were also made to correlate char value with colour degradation, both by measuring the colour before and after heating the sample at 150° C under a pressure of 100 p.s.i. of oxygen and by measuring the colour of a 10 per cent distillation residue.

It had been observed that a high residue on evaporation was commonly associated with high char value, although no firm relationship could be established. A series of measurements of the temperature of the wick and base of the flame in the IP Burning Test lamp showed that the temperature in the char forming region was roughly the same as the end point of the kerosine. Residue on evaporation tests (similar to IP 131) were therefore carried out at 260° C, using a jet of nitrogen instead of air. In order to obtain better sensitivity, the sample was first distilled to a 10 per cent residue, but no correlation with char value was obtained.

More promising results were obtained from the determination of the carbon residue (IP 14) of a short distillation residue. On distillation of a kerosine the carbonizable material was shown to be concentrated in the residue, and plotting the Ramsbottom carbon residues of 0·5 per cent residues from a number of kerosines against their char value gave a linear relationship. Tests by this method could be completed in about five hours. Unfortunately a number of kerosines gave values which fell a long way off this line and, indeed, appeared to be on a second line parallel to, but some distance from, the first. Work on this method was therefore discontinued.

Trials were then made of a method in which a 10 per cent residue from the distillation of a litre of kerosine was burned in the normal manner. Small oil reservoirs for use with IP wick holders were designed in which the overall height of the lamp to the top of the wick guide was only about half that of the IP lamp in order to avoid the excessive drop in flame height that occurred when burning the residue in a deeper lamp. The time required to carry out this test was about six hours.

Sufficiently large differences were obtained between kerosines of high and low char values, but all results were markedly high and repeatability was not good. It was then suspected that the high values, poor repeatability, and non-dependence of char weight on length of residue were due to oxidation of the residue while it cooled at the end of the distillation, and a further series of tests was carried out on kerosine distilled under nitrogen. IP 24-hour burning tests on this kerosine and on the 90 per cent distillate obtained from it gave the values presented in Table I.

TABLE I

IP 24-Hour Burning Tests

Sample	Actual wt of char, mg	IP char value, mg/kg
P. Kerosine before distillation .	8·35	17·4
Q. Kerosine de-aerated under nitrogen . . .	8·2	17·1
R. 90% distillate from kerosine P (distilled under nitrogen.	1·0	2·1

* MS received 5 April 1954.

† Anglo-Iranian Oil Co. Ltd., Research Station, Sunbury-on-Thames.

Preliminary rapid burning tests on short distillates and residues from the distillation of 1–1·7-litre portions of the kerosine P under nitrogen gave the results shown in Table II, and indicate that the majority of the char is concentrated in the distillation residue.

TABLE II

Preliminary Rapid Burning Tests

Distillate or residue from distillation under nitrogen	Burning time, hours	Actual wt of char	
		mg	mg/kg
Distillate :			
80 to 90% vol . .	3	0·6	9·5
90 to 95% vol . .	3	0·8	14·0
Residue :			
10% vol . . .	3	3·4	53
10% vol . . .	3	2·5	42
10% vol (re-aerated when cold) . .	3	2·5	44
Residue :			
10% vol . . .	5	5·4	68
10% vol . . .	5	5·1	56
Residue, 5% vol . .	3	3·3	72

The values given in Tables I and II show that 3- or 5-hr burnings of the 5 or 10 per cent residues from 1 to 1·7-litre portions of the kerosine P gave actual weights of char that were appreciably smaller (and therefore less accurately weighed) than those from a 24-hr IP burning test on the original kerosine. In order to reduce the difference between the weights of char from the rapid and 24-hr tests, the former was modified : (*a*) by increasing the quantity of kerosine distilled from 1 to 2 litres and, (*b*) by changing the length of residue to 7 per cent so as to obtain a quantity that was of convenient size for burning in five hours.* These are the conditions used in the method finally adopted and described in the following paragraphs. Under these conditions kerosine P gave 6·7 mg of actual char as compared with 8·35 by the IP 24-hr test.

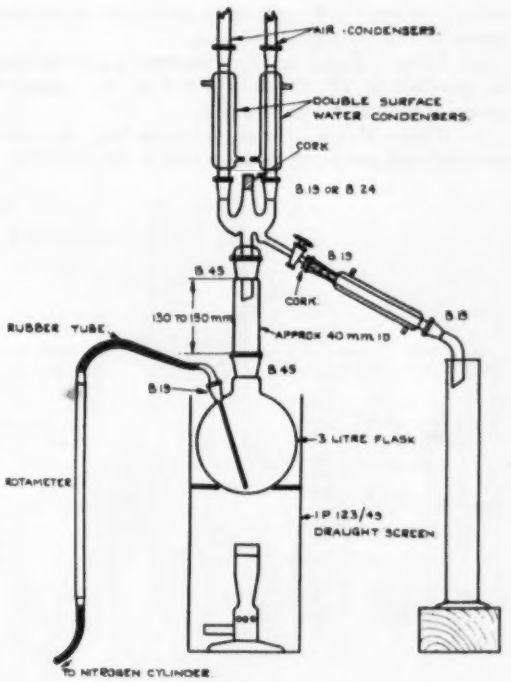


FIG 1

DISTILLATION APPARATUS

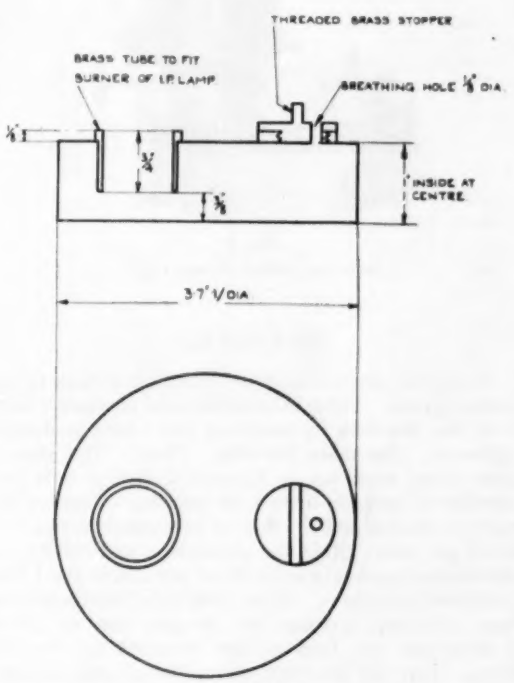


FIG 2

OIL RESERVOIR FOR LAMP

METHOD

1. *Outline*

Two litres of the sample are distilled rapidly under nitrogen to yield a 140 ml residue, and this residue is burned in a lamp, consisting of an IP burner fitted (IP 10) into a small oil reservoir. The char formed is weighed after a burning time of five hours and the weight of char obtained per kilogramme of kerosine distilled is converted to the probable IP char value by reference to a conversion graph.

2. *Apparatus*

(a) *Distillation Apparatus.*—This (Fig 1) is built up from standard laboratory equipment with the exception of the column, column head, and nitrogen inlet tube. The column is used as a spray trap and packed for about half its length with 20 to 30 mm lengths of 6 to 7 mm outside diameter glass tube. The column head differs from the standard in having sockets for two condensers, thus reducing the vapour

* The normal consumption of kerosine in an IP lamp is 20 g/hr.

velocity in each. The nitrogen inlet tube must reach nearly to the bottom of the flask.

(b) *Lamp.*—This consists of the burner and chimney as specified in IP 10/53(T) fitted to the small oil reservoir shown in Figs 2 and 3.

(c) *Wick.*—Pieces of wick, 4 inches long, are used, specified and prepared as described in IP 10/53(T).

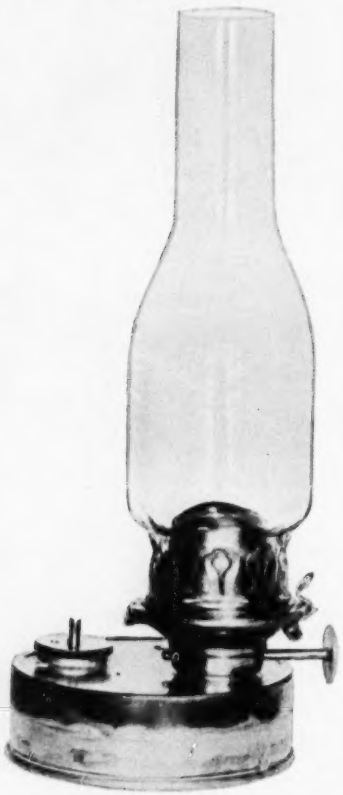


FIG 3
MODIFIED CHAR VALUE LAMP

PROCEDURE

Weigh the clean and empty distillation flask to the nearest gram. Filter the kerosine and measure 2 litres of it into the flask by means of two 1-litre graduated cylinders. Assemble the still. (*Note:* The ground glass joints must *not* be lubricated, though it is permissible to moisten them with sample.) Turn on the nitrogen and adjust the flow to between 0·75 and 1·25 litres per min. Start the distillation and collect the distillate at approximately 30 ml per min in the 1 litre graduated cylinders. When 1860 ml of distillate have been collected, increase the nitrogen flow to 1·5 to 2 litres/min and turn off the stopcock on the still head. Turn off the heat, and allow the still to cool. The rate of cooling can be increased by blowing a gentle stream of compressed air on the distillation flask. Remove the still head and pour any kerosine distillate retained in it into the residue. Complete the cooling of the flask by partial immersion in cold water before detaching the column. Do not turn off the nitrogen until the flask is nearly cold. Weigh the flask plus residue to the nearest gram.

Prepare the lamp and wick for use according to the instructions given in IP 10/53(T) with the following exceptions:

(i) use a 4-inch length of wick;

(ii) put the dry wick into the burner (*i.e.* not moistened with the oil under test);

(iii) start with the lamp clean and dry because it is not possible to wash it out with the sample.

Pour the residue from the distillation into the lamp. Allow the oil to soak up the wick. Trim the wick to give the correct size of flame. Extinguish the flame and weigh the lamp plus oil to the nearest 0·5 g. (The up-draught caused by the flame would cause a significant error in the apparent weight of the lamp plus oil.) Re-light the lamp and allow it to burn for five hours (±5 min), checking the adjustment of the flame after the end of the first half hour.

Extinguish the flame at the end of five hours and weigh the lamp plus remaining oil to the nearest 0·5 g. Measure the amount of char formed by the following modification of the procedure given in IP 10/53(T):

Turn up the wick and cut off approximately ½ inch from the charred end. Place this short length of wick, together with any pieces of char which have become detached, in a small beaker. Remove any char adhering to the wick-guide by gentle scraping with metal forceps and add it to the beaker. Wash the contents of the beaker free from kerosine by adding a small volume of 60/80 petroleum spirit and warming on a hot plate so that it simmers for about half a minute. Decant off the petroleum spirit. Repeat this warm extraction three more times with fresh portions of petroleum spirit. After decanting off the last portion of petroleum spirit, dry the contents of the beaker in an oven at approximately 105° C until odour and visual inspection indicate that all the hydrocarbon has been removed. This usually takes from 10 to 15 min in the oven. After this, separate and weigh the char by the procedure given in IP 10/53(T).

CALCULATION

If:

D = weight in g of sample distilled (this can be taken as 2000 times the specific gravity of the sample at the temperature of measurement);

R = weight in g of residue from the distillation;

B = weight in g of residue burned;

C = weight in mg of char on the wick;

W = weight in mg of char formed per kg of sample.

Then: $$W = 1000CR/BD$$

TABLE III

Five Hour Burning Tests—Correlation of Results with IP Char Value

Kerosine	IP char value		Operator L					Operator M				
			Five-hr test (wt char per kg kero distilled)		Predicted IP char from 5-hr test (Curve L, Fig 4)			Five-hr test (wt char per kg kero distilled)		Predicted IP char from 5-hr test (Curve M, Fig 4)		
	Individual results, mg/kg	Mean results, mg/kg	Individual results, mg/kg	Mean results, mg/kg	Individual results, mg/kg	Difference from mean IP char		Individual results, mg/kg	Mean results, mg/kg	Individual results, mg/kg	Difference from mean IP char	
						Mg/kg	% of IP char				Mg/kg	% of IP char
A	1·3	1·15	0·95	0·975	1·1	−0·05	4·4	—	—	—	—	—
	1·0	—	1·0	—	1·2	+0·05	4·4	—	—	—	—	—
B	3·2	3·6	1·9	1·95	3·5	−0·1	2·8	2·3	2·1	4·1	+0·5	13·9
	4·0	—	2·0	—	3·8	+0·2	5·6	1·9	—	3·0	−0·6	16·7
C	10·0	10·2	2·8	3·35	7·0	−3·2	31·4	—	—	—	—	—
	10·4	—	3·9	—	12·5	+2·3	22·5	—	—	—	—	—
D	10·4	10·4	3·3	3·6	9·4	−1·0	9·6	4·0	4·0	11·0	+0·6	5·8
	10·4	—	3·9	—	12·5	+2·1	20·2	3·9	—	10·6	+0·2	1·9
	—	—	—	—	—	—	—	4·0	—	11·0	+0·6	5·8
E	17·5	18·7	4·8	4·9	18·1	−0·6	3·2	—	—	—	—	—
	18·8	—	4·8	—	18·1	−0·6	3·2	—	—	—	—	—
	19·8	—	4·8	—	18·1	−0·6	3·2	—	—	—	—	—
	—	—	5·7	—	22·4	+3·7	19·8	—	—	—	—	—
	—	—	4·3	—	15·1	−3·6	19·3	—	—	—	—	—
	—	—	5·2	—	20·0	+1·3	7·1	—	—	—	—	—
F	22·7	24·5	5·5	6·2	21·5	−3·0	12·2	—	—	—	—	—
	26·2	—	6·9	—	26·8	+2·3	9·4	—	—	—	—	—
G	13·3	14·6	—	—	—	—	—	4·9	4·5	15·5	+0·9	6·2
	16·0	—	—	—	—	—	—	4·1	—	11·6	−3·0	20·6
H	22·0	22·2	—	—	—	—	—	6·8	6·45	22·8	+0·6	2·7
	21·5	—	—	—	—	—	—	6·1	—	20·5	−1·7	7·7
	23·1	—	—	—	—	—	—	—	—	—	—	—
I	21·7	22·2	—	—	—	—	—	6·5	8·1	21·9	−0·3	1·4
	22·8	—	—	—	—	—	—	8·6	—	27·2	+5·0	22·5
	—	—	—	—	—	—	—	9·3	—	28·7	+6·5	28·0

Calculate W to the nearest 0·1 mg/kg and convert it to the probable IP char value by means of a correlation curve prepared by plotting W against the IP char value for a number of kerosines of known char value.

RESULTS

Tests by this method were carried out by two operators using two different sets of apparatus and nine kerosines. The results are given in Table III.

The curves in Fig 4 relate the mean results obtained by operators L and M respectively with the IP char values of the kerosines examined. The deviations of

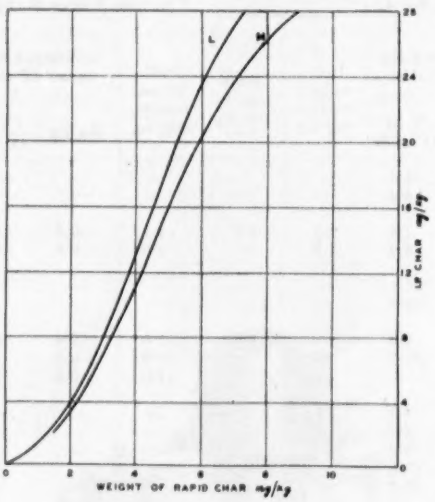


FIG 4

CORRELATION CURVES BY OPERATORS L AND S

the individual experimental points from these curves are given in Table III, and can be used to assess the precision of the rapid method for predicting IP char. A statistical survey on a 95 per cent probability basis shows that the precision of the rapid method is not very different from the published precision of the IP burning test. This is illustrated in Table IV.

Tests by this method can be completed in approximately eight hours. Of this time, one and a half to two hours are employed in filtering and distilling the kerosine, five hours in burning the residue and the remaining time is used in separating and weighing the char. The amount of char obtained for weighing is nearly the same as that from tests by IP 10/53(T), and the char formed was found to be similar to IP char in appearance and ease of handling.

TABLE IV

Precision of Predicted Char Values

IP char value, mg/kg	Rapid method		IP method	
	Standard deviation * S_r, mg/kg	Maximum deviation of rapid char from IP char, mg/kg	IP repeatability (max difference between results), mg/kg	IP reproducibility (max difference between results), mg/kg
0 to 10	0·47	0·9	2	4
10 to 20	2·36	4·6	4	6
20 to 30	20%	39% of IP char value †	20% of mean char value	30% of mean char value

* Standard deviation of difference between rapid and IP char results.

† This value is very approximate.

CONCLUSIONS

The results of an IP char value test can be predicted by the method described herein with an accuracy nearly equal to that of the published precision of IP 10/53(T). Results can be obtained in an elapsed time of eight hours instead of the 27 hours required before the result of an IP test becomes available, and the method is therefore suitable for use as a works control test when rapid results are required.

ACKNOWLEDGMENTS

The authors wish to thank their colleagues at Sunbury, and in particular M. R. Short, for their assistance. They also wish to thank the chairman and directors of the Anglo-Iranian Oil Company for permission to publish this work.

CARBON RESIDUE—CONRADSON OR RAMSBOTTOM?

CARBON residue tests are carried out on petroleum products with a view to indicating the tendency of the products to form deposits of carbon when they are used under conditions which may include distillation. Thus, they are used in the quality assessment of automotive lubricating oils, diesel fuel, and underboiler fuel.

The " Conradson " test first appeared in the literature in 1912, and the " Ramsbottom " test ten years later, the latter being devised to simplify the apparatus and to prescribe test conditions more amenable to precise control. The " Conradson " test was adopted, under the designation D47, as a tentative standard by the ASTM in 1917, and was elevated to full standard status in 1918. In 1924 the test again became a tentative standard, designation D189, and was advanced to full standard status again in 1928.

The " Conradson " test appeared in the 1st edition of IP *Standard Methods* in 1924, designation G09, and the " Ramsbottom " as G09A in the 2nd edition in 1929. Both tests appear in the current publications of both the ASTM and the IP—Conradson IP 13/42, ASTM D189/52—Ramsbottom IP 14/45, ASTM D524/52T. However, experience of the test in the interim has occasioned a preference for the Ramsbottom test, and in 1946 the ASTM included the following footnote to D189/46 : " The Committee responsible for the development of this method urges that its use be discontinued and that instead the more expedient Ramsbottom carbon residue test ASTM Method 524 be followed."

In 1947 IP 13/42 introduced a similar note and has retained it up to the present date.

The preference for the Ramsbottom test is based on the greater simplicity of the apparatus and a test procedure which is the more reproducible, factors conducive of better precision as is indicated by the following data taken from IP *Standard Methods* 13th Edition.

Precision

	Conradson Repeatability	Reproducibility
Carbon residue .	20% of mean	20% of mean
Carbon residue on 10% residuum :		
0·1% and above	40% of mean	40% of mean
Below 0·1% .	More than 40% of mean	More than 40% of mean

Ramsbottom Carbon residue	Repeatability	Reproducibility
10%	6% of mean	10% of mean
1%	8% of mean	14% of mean
0·5%	10% of mean	16% of mean
0·1%	40% of mean	60% of mean

These figures do not take into account later information which demonstrated the superior precision of the Ramsbottom test over the whole range.

The Conradson test is still in use, how widely in comparison with the preferred test is not known, and " Conradson carbon residue " still appears in specifications. However, there is a growing tendency to calculate the Conradson carbon residue from the result of a Ramsbottom value, and ASTM publish a conversion table for that purpose. The extent to which the use of this table may be universally practicable is not known. Other and different tables are in use in the U.K. which show a better correlation with values determined on the products in the laboratories in which the tables are used.

At its meeting held on 1 December 1953 the Miscellaneous Tests Panel of IP Sub-Committee No. 6, Lubricants, formally renounced the test declaring its preference for the Ramsbottom procedure and the former test passed from the responsibility of No. 6 Sub-Committee to No. 4 Sub-Committee—Gas, Diesel, and Fuel Oils.

No. 4 Sub-Committee has agreed that, in view of the footnote 2 to IP 13/42, the continued inclusion of that method in *Standard Methods* is anomalous, and sees three possible alternative procedures to rectify the position, namely :

(*a*) to delete IP 13/42 forthwith as an obsolete method ;

(*b*) to encourage the conversion of Ramsbottom to Conradson figures by publishing a conversion table ;

(*c*) to delete footnote 2.

It was agreed that (*c*) would be a regrettable and retrograde step.

The Sub-Committee is of opinion that the method should be regarded as obsolete, and is considering recommending its deletion from the 15th edition of *Standard Methods*. At the same time, it is endeavouring to produce a conversion table for the conversion of Ramsbottom values to Conradson figures for whatever purpose the latter may be required. Such a table must, naturally, be generally acceptable.

In order that its final decision may be in accord with the best interests of the industry, No. 4 Sub-Committee will be grateful to have the views of all to whom this matter is of importance and who will communicate those views to the Institute of Petroleum.

THE STABILITY AND COMPATIBILITY OF FUEL OIL AND DIESEL FUEL*

CONTRIBUTED DISCUSSION

G. C. Ackroyd (Fuel Research Station, Greenwich) wrote: This paper is to be welcomed as a most valuable contribution both to the chemistry of residual oils and to the problems encountered in their utilization. It is evident that the asphaltenes present is these oils are very intimately associated with the stability and compatibility of the oils and also, as Dr Winward mentions, with "viscosity build-up on storage." The theory that the asphaltenes exist in the form of micelles, peptized by the more aromatic constituents of the maltenes, is adopted. There is no doubt that this micelle theory is the most attractive explanation so far advanced to account for the behaviour of asphaltenes, but it does appear from a review of the literature that the evidence supporting the theory is based more on inference than on fact. No one has yet seen a micelle, and yet the properties attributed to them would appear to indicate an aggregate at least big enough to be seen with the aid of an electron microscope. D. L. Katz and K. E. Beu (*Ind. Engng Chem.*, 1945, **37**, 195) examined undiluted oils and asphalt under the electron microscope and came to the conclusion that the micelles, if they exist at all, are less than 65 Å in diameter, the maximum resolution obtainable with the instrument used. Particles as small as this hardly come into the colloidal range. However, if it is assumed that the asphaltene micelles are long and so narrow that they are not able to be detected under the electron microscope, the micelle theory and the electron microscope observations may be reconciled. Moreover, a long, thin micelle might well account for the changes observed in the flow properties of an oil on storage, better than a more compact micelle.

Work, which will shortly be published, has been carried out at the Fuel Research Station on residual oils which age on storage and have a pour point influenced by the previous thermal history of the oil. By suitable choice of reheat temperature such oils can be put in either a minimum or a maximum fluidity condition. The minimum fluidity oil gives a higher yield of precipitate when diluted with 10 parts of pentane at room-temperature than does the maximum fluidity oil. Moreover when such oils are examined by the Oliensis spot test, the asphaltenes in the maximum fluidity oil are found to be appreciably less well peptized than those in the minimum fluidity condition. This difference in the state of peptization of the two oils is important. Normally oils as blended at a refinery are nearer the maximum fluidity condition than the minimum fluidity condition, but with age tend to revert towards a lower fluidity condition; the peptization of the asphaltenes therefore tends to increase, the micelles growing larger. Thus, with age the stability and compatibility of an oil may tend to improve, but at the expense of a deterioration in the flow properties. It must also be noted that heating such oils to improve their pumpability may alter the miceller structure, and cause an otherwise stable oil to become unstable.

D. R. Bailey (in reply) wrote: The probable reason why Katz and Beu failed to "observe" asphaltenes with the aid of the electron microscope has been referred to already. It is perhaps not out of place, however, to mention that for the same reason polymer molecules in plasticizer solutions are, as far as we know, not shown up by the electron microscope. Nevertheless, it is certain that their molecular weights are very high and their particle sizes much greater than 65 Å.

It will be realized that the simplest approach was adopted in presenting this paper, and hence the objection that the evidence supporting the theory of micelle formation is based more on inference than on fact, strictly requires a formal review of the evidence available. Considerations of space prevent more than a very brief outline of this evidence being given, but we hope that the following will indicate the type of evidence upon which the micelle theory for asphaltic systems is based.

Asphaltenes and asphaltene fractions never consist of a single component. In residual fuel oils or asphaltic bitumens a broad range of asphaltene-like structures is present, differing in solubility in hydrocarbons as a consequence of differences in polarity, polarizability, and molecular weight.

The molecular weight of asphaltene molecules appears to be of the order of 1000 to 3000 and they can be molecularly dispersed in such solvents as benzene or carbon disulphide. They are insoluble, however, in aliphatic hydrocarbons.

It is thus fair to assume that each asphaltene component requires a characteristic minimum of aromatics in order to be completely miscible with a mixture of aromatic and aliphatic hydrocarbons. Below this aromatic content the asphaltenes are completely insoluble.

In contrast with many mixtures of homologous polymers, a mixture of asphaltenes is not fractioned into its single components by the increasing addition of an aliphatic hydrocarbon to its solution in an aromatic hydrocarbon. It is an experimental fact that successive asphaltene fractions each consist of a range of asphaltenes, and each may again be fractionated under the same conditions as applied in the first fractionation. This establishes that the solubility of an asphaltene component is strongly influenced by the presence of other asphaltene components. The same effect is directly demonstrated when two asphaltene fractions in dilute solution with low molecular weight hydrocarbons are mixed. The minimum aromatic content required to dissolve the asphaltenes lies between those of the separate asphaltene fractions (Reference 11, Page 6, Table II—Additivity of p_a value).

It may thus be concluded that when the aromaticity is too low to maintain the asphaltenes in true solution, association of the different asphaltene components will occur. As natural asphaltene systems consist of a very broad range of analogous components, such an association will lead to aggregates (micelles) of a large number of molecules under suitable conditions.

This phenomenon may to a certain extent be compared with the formation of micelles when a concentrated solution of a molecularly dispersed soap (*i.e.* a concentrated solution of homologous soap molecules in an alcohol) is strongly diluted with water.

---

* Pages 138–150.

It is also worth noting that an objection against the micelle theory for asphaltene systems also holds for micelle formation of soaps in water. However, there is no doubt of the existence of soap micelles.

I certainly agree with Mr Ackroyd that it appears very likely that the state of peptization of the asphaltenes has some influence on the flow properties of waxy fuels. In this connexion the experimental evidence he gives is particularly interesting as regards the difference in the state of peptization of the asphaltenes depending on whether the fuel is in a condition of minimum or maximum fluidity. However, the possibility should not be excluded that precipitation of asphaltenes by pentane at room temperature might lead to co-precipitation of wax and that in the minimum fluidity condition more wax has been precipitated.

It is noteworthy, however, that the Oliensis test points to a poorer state of peptization of the asphaltenes when the fuel is in a condition of maximum fluidity, while on the other hand less precipitation is obtained on dilution with pentane. It is possible that less precipitation of wax means more wax in solution, resulting in a more aliphatic, oily medium and hence less well peptized asphaltenes. Further, as the Oliensis test includes dilution and heating of the fuel it is difficult to be certain about the state of peptization of the asphaltenes in the test.

Although we, too, have observed that some fuel oils on ageing tend to revert towards a lower fluidity condition, in our opinion no general rule can be formulated to account for their behaviour on storage, since this is dependent upon composition and the thermal cycles to which the fuel is subject during the storage period.

OBITUARY

ROBERT ASHLEY BALDRY

We record with regret the death in July 1952 of Robert Ashley Baldry, an Associate Member of the Institute since 1924. He was an M.A. of Cambridge, a Fellow of the Geological Society, and a Fellow of the Royal Geographical Society.

The whole of his active career was spent in the service of Lobitos Oilfields Ltd., which company he joined in 1921 as assistant geologist and eventually became chief geologist. He retired in 1947.

An obituary notice in the *Proceedings of the Geological Society of London* records that he mapped a considerable part of the Tertiary beds, of great complexity, of Northwest Peru, and that his theory of gravitational sliding led to many years of successful drilling for petroleum in Peru. This theory was the subject of a paper published by the Geological Society in 1938.

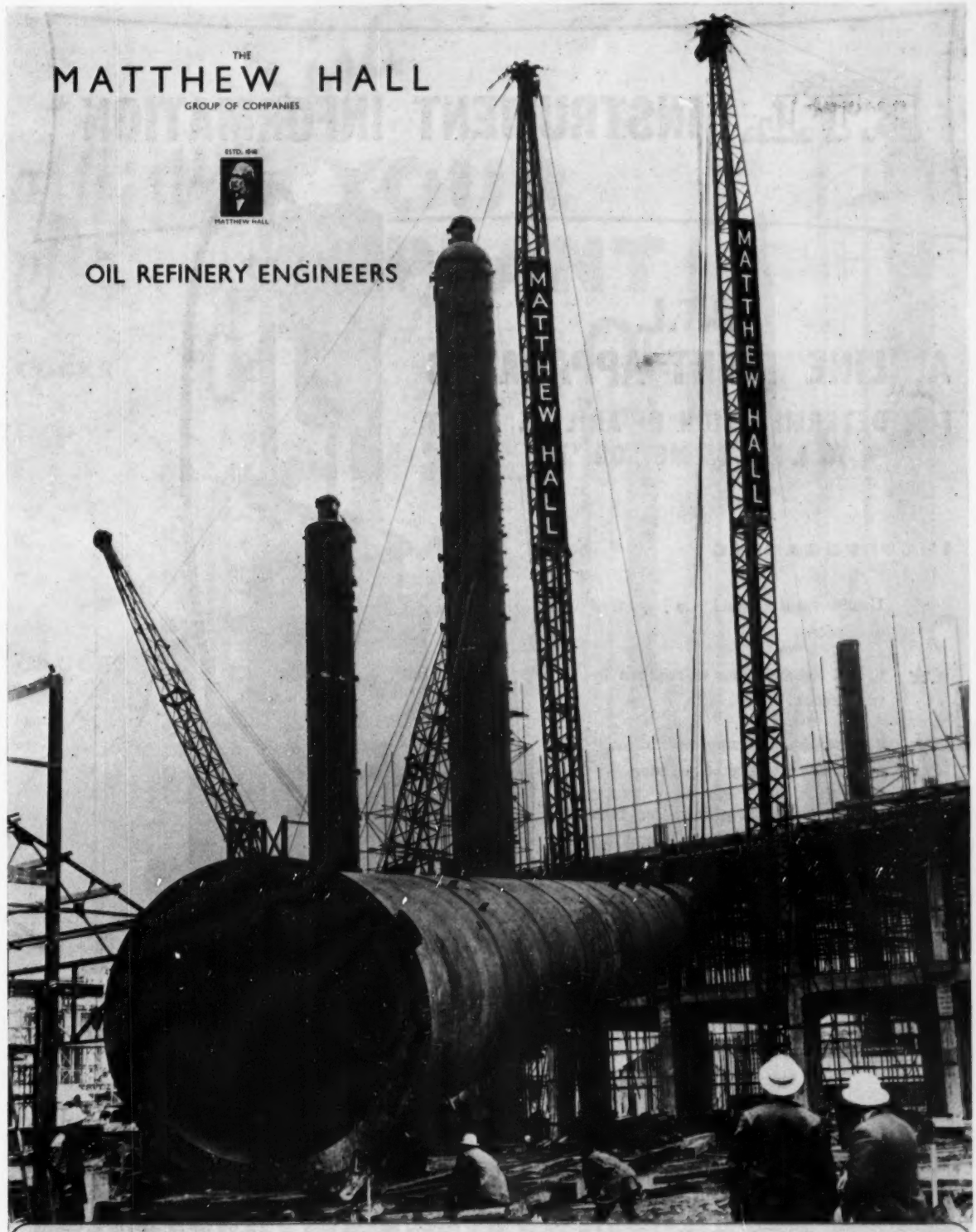
ERRATA

In Table V, p. 53, of the February Journal, for "Tributane" read "Tributyl"; for "systems [6]" (6th line, p. 54) read "systems [8]"; insert "organic" between the words "basic" and "compounds" (6th line, under the heading PRACTICAL APPLICATION, p. 54); and insert the following after Reference 2: [3] Buchwald, H., and Wood, L. *Anal. Chem.*, 1953, **25**, 664. [4] Katzin, L. I., and Gilbert, E. *J. Amer. Chem. Soc.*, 1953, **75**, 801. References 3, 4, 5, 6, and 7 should be altered to 5, 6, 7, 8, and 9 respectively.

THE
MATTHEW HALL
GROUP OF COMPANIES

ESTD. 1918

OIL REFINERY ENGINEERS



THE MATTHEW HALL GROUP OF COMPANIES

MATTHEW HALL & CO., LTD. — MATTHEW HALL (PTY.) LTD.
KELCO (METALS) LTD. — GARCHEY LTD.

LONDON . . . . . Dorset Square, N.W.1	JOHANNESBURG 52, Commissioner Street	BELFAST . . . . . Greenwood Avenue
MANCHESTER . . . . . 14, Lloyd Street	GERMISTON . . . . . Wadeville	DUBLIN . . . . . 29, Westland Row
GLASGOW . . . . . Dykehead Street, E.2	DURBAN . . . . . 100-102, Williams Road	WEST INDIES . . . . . Kingston, Jamaica
BRISTOL . . . . . St. Stephen's Street	CAPE TOWN . . Epping Industrial Estate	BULAWAYO . . . . . Ironbridge Road
	WELKOM . . . . . Third Street	

a

i

B.T.L. INSTRUMENT INFORMATION

B.T.L.
ANILINE POINT APPARATUS

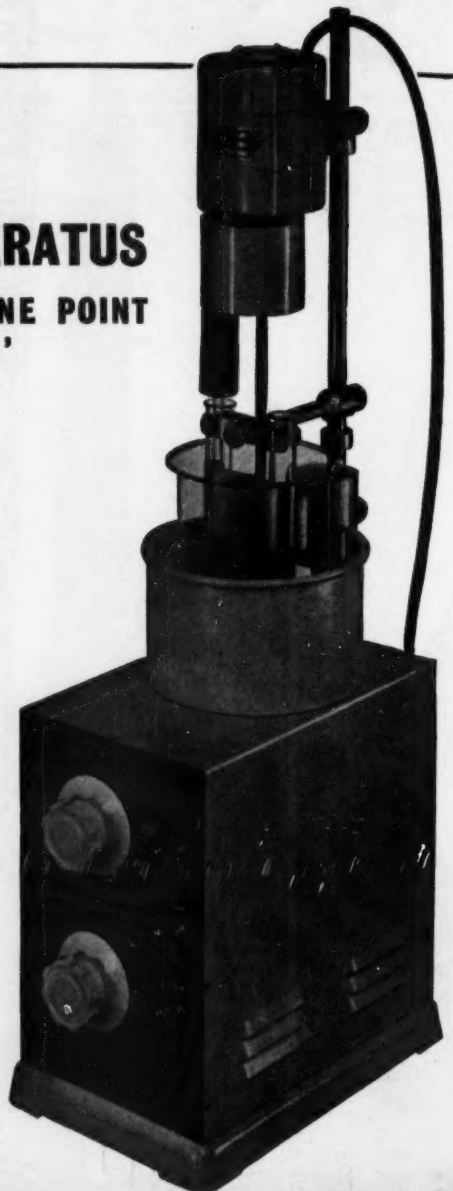
FOR DETERMINATION OF ANILINE POINT TO I. P. 2/53 METHOD 'D'

INCORPORATING

- ★ U-tube and shield to specified dimensions.
- ★ special sighting lamp as required by specification.
- ★ infra-red heating lamp with rheostat control for intensity of radiation.
- ★ stirring unit and paddles for bath and U-tube with speed control by rheostat.
- ★ suitable for use on 230V-250V A.C. only.

PRICE £27.10.0 EX WORKS

Full particulars of this apparatus are given in Technical Leaflet T.13 sent on request.



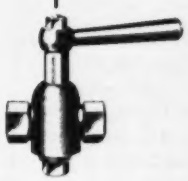
BT L

Member of SCIEX

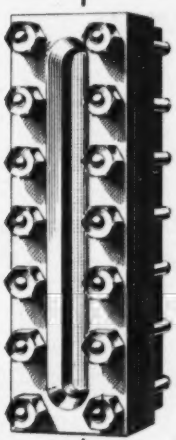
BAIRD & TATLOCK
(LONDON) LTD.
Scientific Instrument Makers
FRESHWATER ROAD, CHADWELL HEATH, ESSEX

Klingerise YOUR PLANT

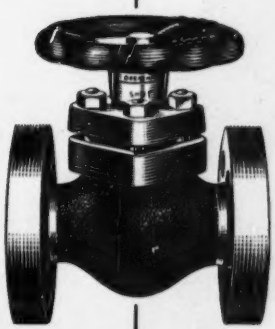
COCKS



GAUGES



VALVES



INSTALL *Klinger* FITTINGS

Write for the Klinger Master Catalogue which describes the complete range of Klinger products, compressed asbestos jointings for all purposes, valves, cocks, level gauges, synthetic and silicone rubbers.

RICHARD KLINGER LIMITED, KLINGERIT WORKS, SIDCUP, KENT, ENGLAND

Agents throughout the World

Manufacturing Licensees for Canada

JOSEPH ROBB & COMPANY, LIMITED
5575, COTE ST. PAUL ROAD, MONTREAL, 20, CANADA
Telephone: WILBANK 3181 Cable: ROBCO
Branches at: SYDNEY, N.S., HALIFAX, N.S., OTTAWA, Ont., TORONTO, Ont., HAMILTON, Ont., WINNIPEG, Man., EDMONTON, Alta., VANCOUVER, B.C.

Manufacturing Licensees for U.S.A.

THE KLINGER CORPORATION OF AMERICA
95, RIVER STREET, HOBOKEN, NEW JERSEY, U.S.A.
Telephone: HOBOKEN 2-7915 Cable: KLINGDALE
New York
Telephone: WHITEHALL 3-8996

ENGLISH DRILLING EQUIPMENT CO LTD

BILBAO HOUSE, 36–38 NEW BROAD STREET, LONDON, E.C.2

Telephone: LONdon Wall 4941–4 **Telegrams: Bullwheel, Ave, London**

EDECO

REGD. TRADE MARK

The Edeco Twin Jet Bit is recommended for use in conjunction with high velocity drilling fluid circulation. The cuttings are swept upwards by the jet stream, keeping the bottom of the hole clean, allowing FASTER PENETRATION and MORE HOLE per bit.

The Edeco Twin Jet Bits are available with all the cutter designs illustrated in the EDECO Rock Bit Catalogue No. 82.

The Jet Circulation ways are forged into the body of the bit avoiding the necessity for separate Tubes and allowing thicker walls around the circulation passages and, consequently, less danger of "cut outs".

The outlets of these passages are fitted with Tungsten Carbide Nozzles with bore size to suit customer's requirements.

TWIN JET

TYPE VS

SUBSIDIARY COMPANIES

EDECO PROSPECTORS LTD
Barlby Works, Lindley Moor Road,
Nr. Huddersfield, Yorks.
Telephone: Elland 2876/7

EDECO CANADA LTD
10103–80th Avenue,
Edmonton, Alberta.
Telephone: Edmonton 35825

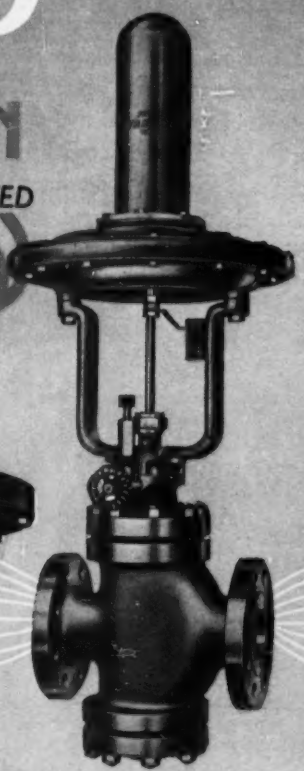
EDECO GERMANY G.M.B.H.
Folschblock C, Hermannstr. 40,
Hamburg, 1.
Telephone: Hamburg 33 39 67

EDECO (TRINIDAD) LTD
P.O. Box 27, San Fernando,
Trinidad, B.W.I.
Telephone: San Fernando 2819

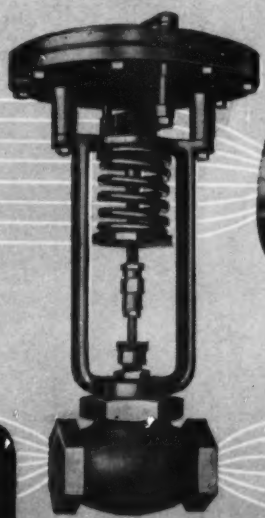
FOXBORO

VALVES

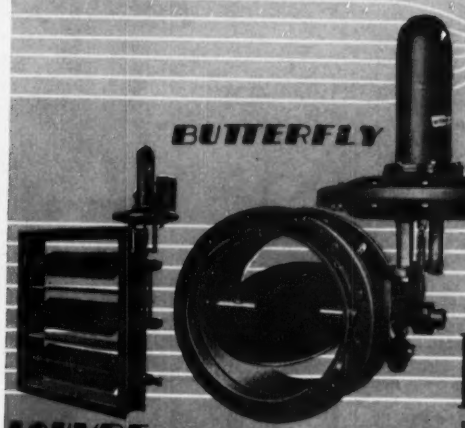
PNEUMATIC DIAPHRAGM MOTOR OPERATED



STABILFLO



BUTTERFLY POPPET



LOUVRE DAMPER

FOXBORO-YOXALL LTD

LOMBARD ROAD, MERTON, LONDON, S.W.19

TELEPHONE: LIBerty 3461/4 TELEGRAMS: YOXBRI, SOUPHONE LONDON

DESIGNED FOR USE WITH FOXBORO PNEUMATIC CONTROL SYSTEMS

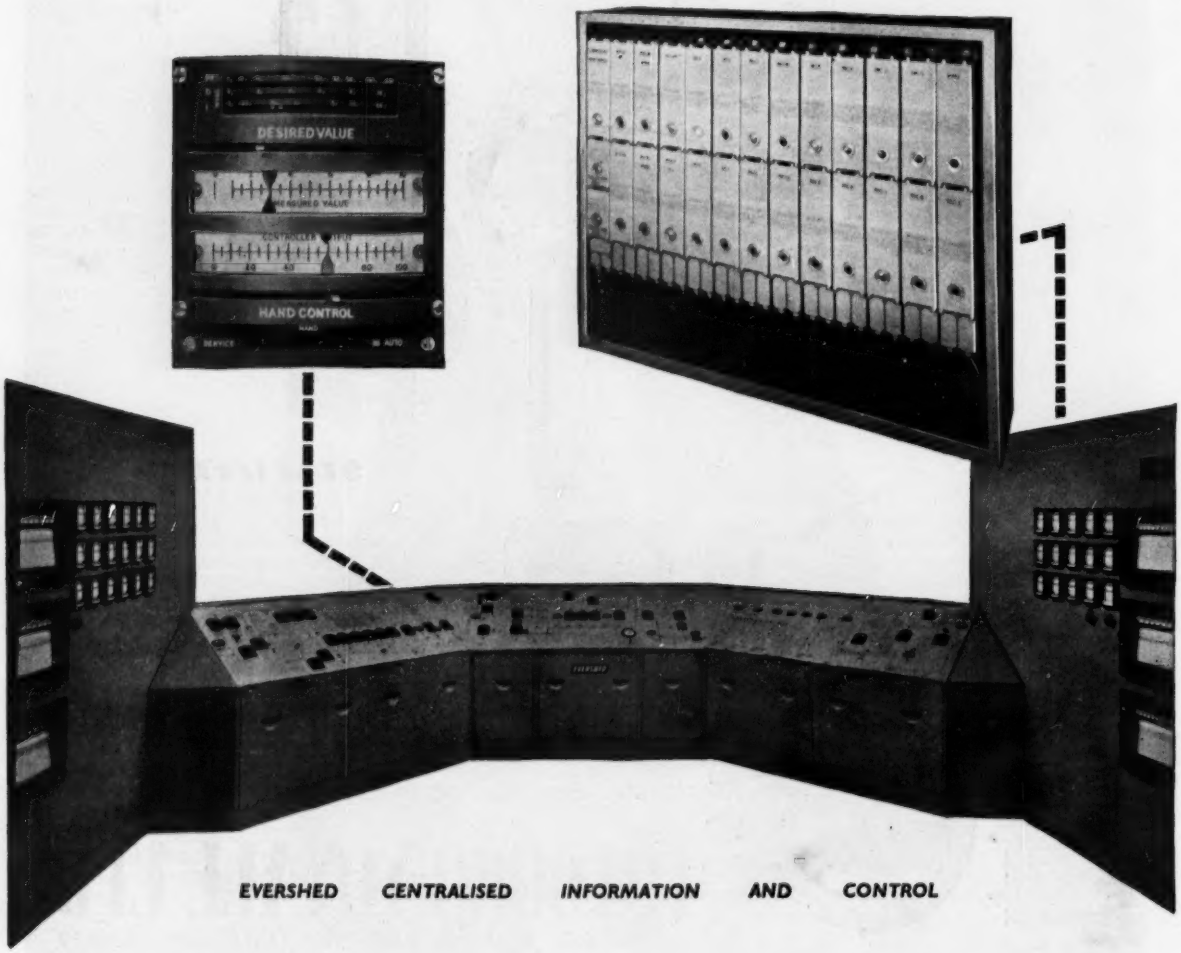
EVERSHED

ELECTRONIC CONTROL

at Aden Refinery

Flow, pressure, level and temperature in two 60,000 B.P.S.D. Crude Distillation Units are automatically controlled from two Central Control Desks at the new Anglo-Iranian Refinery. The process is illustrated on the desk by a coloured mimic diagram with indicators and controller adjustments mounted at appropriate points in the diagram, whilst the controllers themselves are mounted in banks in the wings of each desk. These controllers are connected by cables to the controller adjustments (Miniplaques). Each Miniplaque includes proportional, integral, derivative and desired value adjustments, also indication of measured value and controller output, together with hand/auto and service position controls.

Please write for set of Publications PD 54.



EVERSHED CENTRALISED INFORMATION AND CONTROL

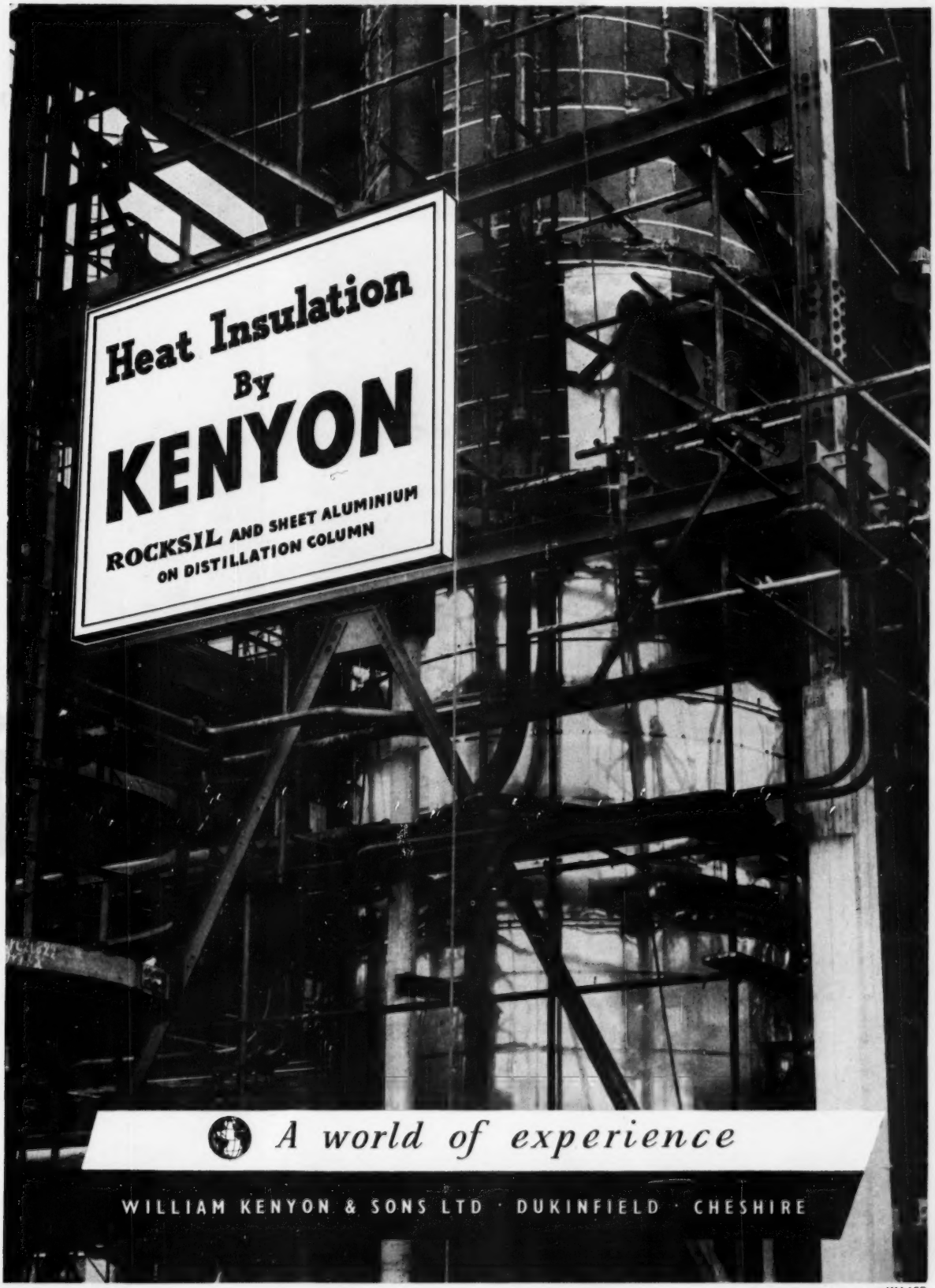
EVERSHED

EVERSHED AND VIGNOLES LIMITED

ACTON LANE WORKS · CHISWICK · LONDON · W4

Telephone: Chiswick 3670 · Cables: Megger, London · Telegrams: Megger, Chisk, London

6/143


Heat Insulation
By
KENYON
ROCKSIL AND SHEET ALUMINIUM
ON DISTILLATION COLUMN
A world of experience
WILLIAM KENYON & SONS LTD · DUKINFIELD · CHESHIRE
KH 159

ANOTHER IMPORTANT CONTRIBUTION TO PETROLEUM PROGRESS

Unifi

A New Catalytic Refining Process to Purify Petroleum Distillates

Universal Oil Products Company is pleased to announce that the UNIFINING process is now available to the petroleum refining industry, and a refiner may secure the benefits of the combined techniques and patent rights of both Universal Oil Products Company and Union Oil Company of California through a single licensing arrangement.

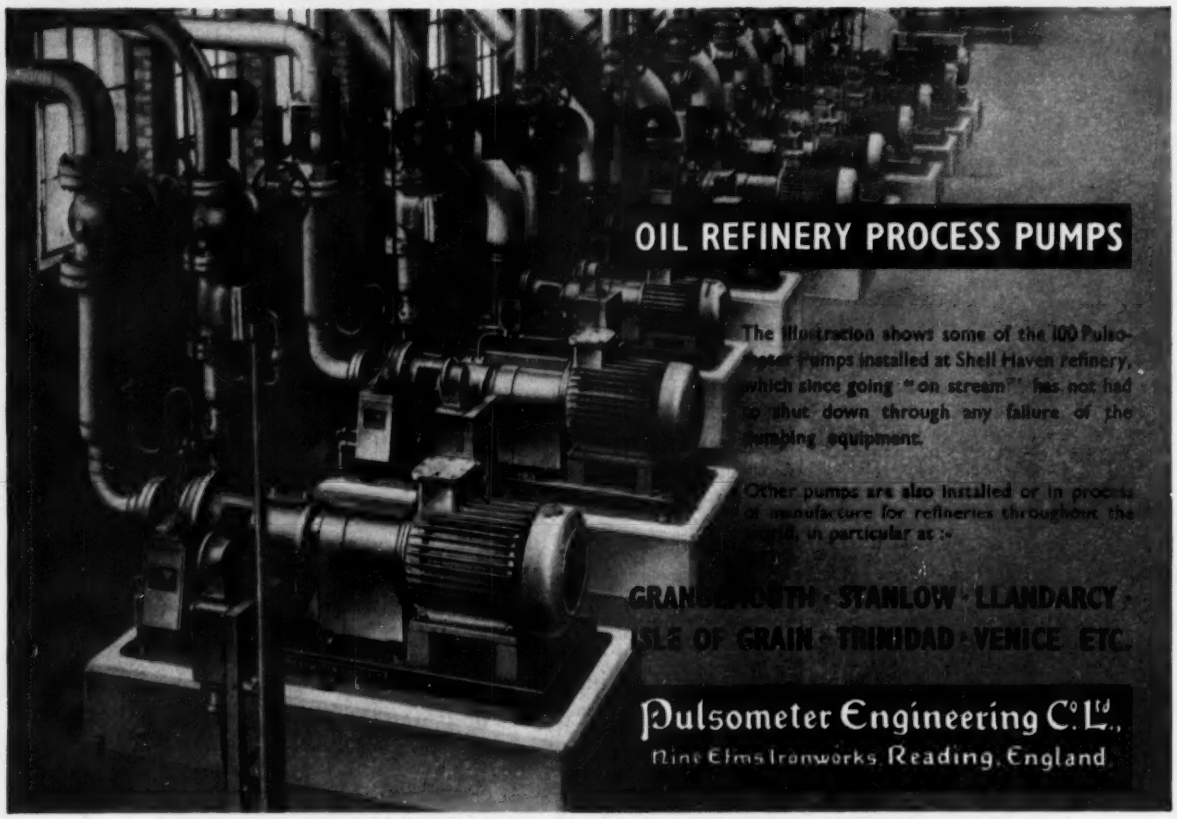
The process uses a cobalt-molybdenum type catalyst to react hydrogen with petroleum distillates, saturating the olefinic hydrocarbons and removing sulphur, nitrogen, oxygen, and other impurities to the degree desired by the refiner.

Excess hydrogen from a UOP Platformer provides an excellent and economical source of hydrogen for the Unifining unit.

n i n g

Unifining is particularly advantageous for pretreating certain types of feed stocks prior to processing in a UOP Platformer. By using Unifining in combination with a Platforming unit, the refiner will find that engineering advantages accrue which will be reflected in lower costs to him.

UNIVERSAL OIL PRODUCTS COMPANY
General Offices: 30 ALGONQUIN ROAD, DES PLAINES, ILL., U.S.A.
UOP® Laboratories: RIVERSIDE, ILLINOIS
Universal Service Protects Your Investment
Representative: F. A. TRIM, BUSH HOUSE, ALDWYCH, LONDON, W.C.2


OIL REFINERY PROCESS PUMPS
The illustration shows some of the 100 Pulso-meter pumps installed at Shell Haven refinery, which since going "on stream" has not had to shut down through any failure of the pumping equipment.
Other pumps are also installed or in process of manufacture for refineries throughout the world, in particular at :-
GRANGEMOUTH · STANLOW · LLANDARCY · ISLE OF GRAIN · TRINIDAD · VENICE ETC.
Pulsometer Engineering Co. Ltd.
Nine Elms Ironworks, Reading, England

STANDARD METHODS

FOR

TESTING PETROLEUM

AND

ITS PRODUCTS

(THIRTEENTH EDITION–1953)

755 pages 168 Diagrams

Price 40s. post free

Obtainable from

The Institute of Petroleum
26 Portland Place, London, W.1

DRILLING MUD:

ITS MANUFACTURE

AND TESTING

By

P. EVANS and A. REID

Reprinted from Transactions of the Mining and Geological Institute of India, 1936.

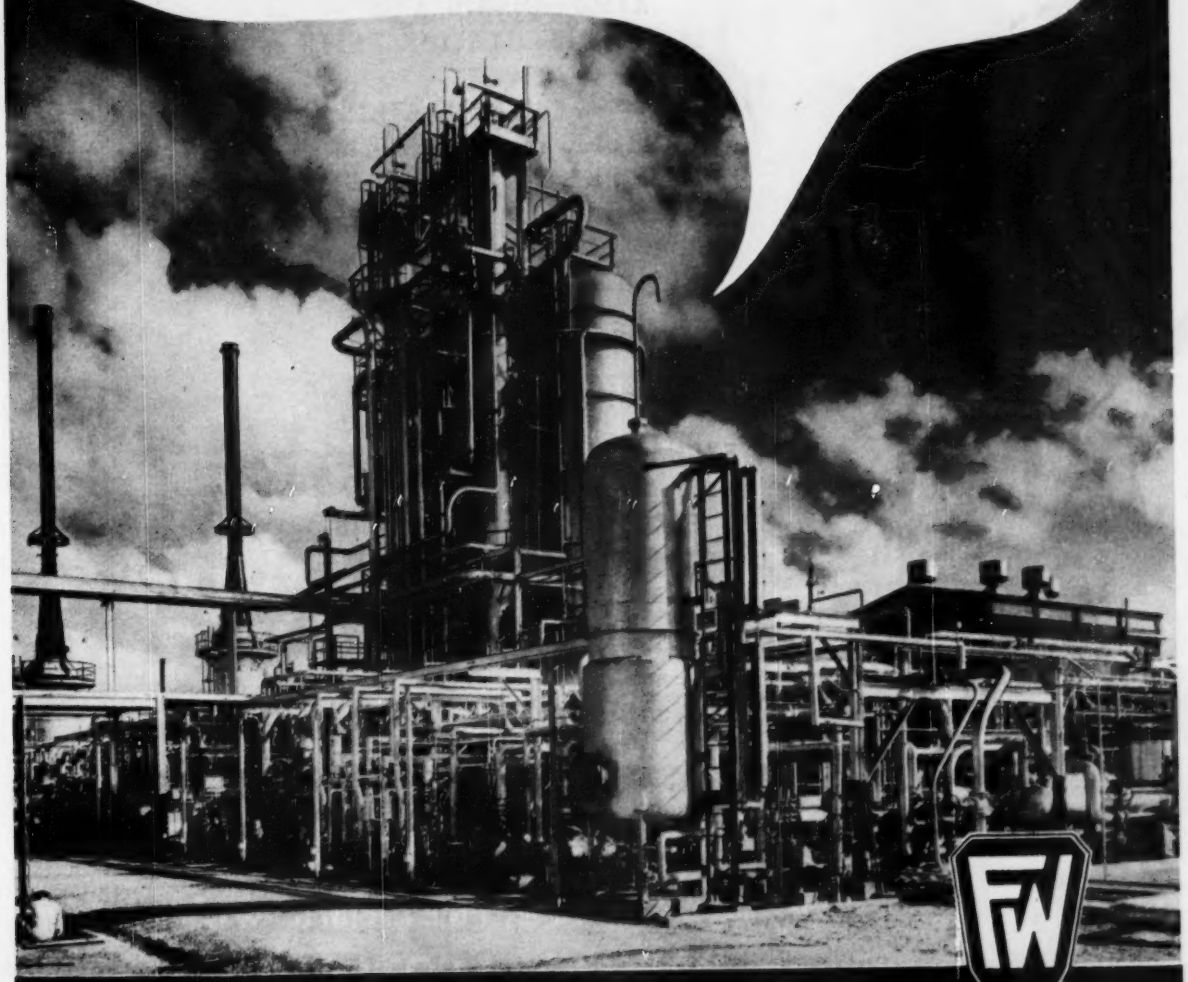
Pages 263 + xxx. Paper covers.
Price 21s. post free.

Obtainable from

The Institute of Petroleum
26 Portland Place, London, W.1

Phenol Treating Plant

Foster Wheeler have designed and built a group of units at the Esso Refinery at Fawley for the production of high grade lubricating oils. The phenol treating plant shown is one of this group which includes units for propane deasphalting, propane dewaxing and clay contacting.



FOSTER WHEELER *London New York and Paris*

Hopwood

CRAIG

COMPREHENSIVE SERVICE

*

REFINERY DESIGN AND CONSTRUCTION

•

ATMOSPHERIC AND
VACUUM DISTILLATION UNITS

•

COMBINED DISTILLATION,
CRACKING, REFORMING AND
VAPOUR PHASE TREATING UNITS

•

PARAFFIN WAX EXTRACTION,
REFINING AND MOULDING

•

GASOLINE RECOVERY
AND STABILISATION UNITS

•

HEAT EXCHANGE EQUIPMENT OF ALL TYPES

•

FRACTIONATING COLUMNS
AND TUBE STILLS

A.F. CRAIG & COMPANY LTD

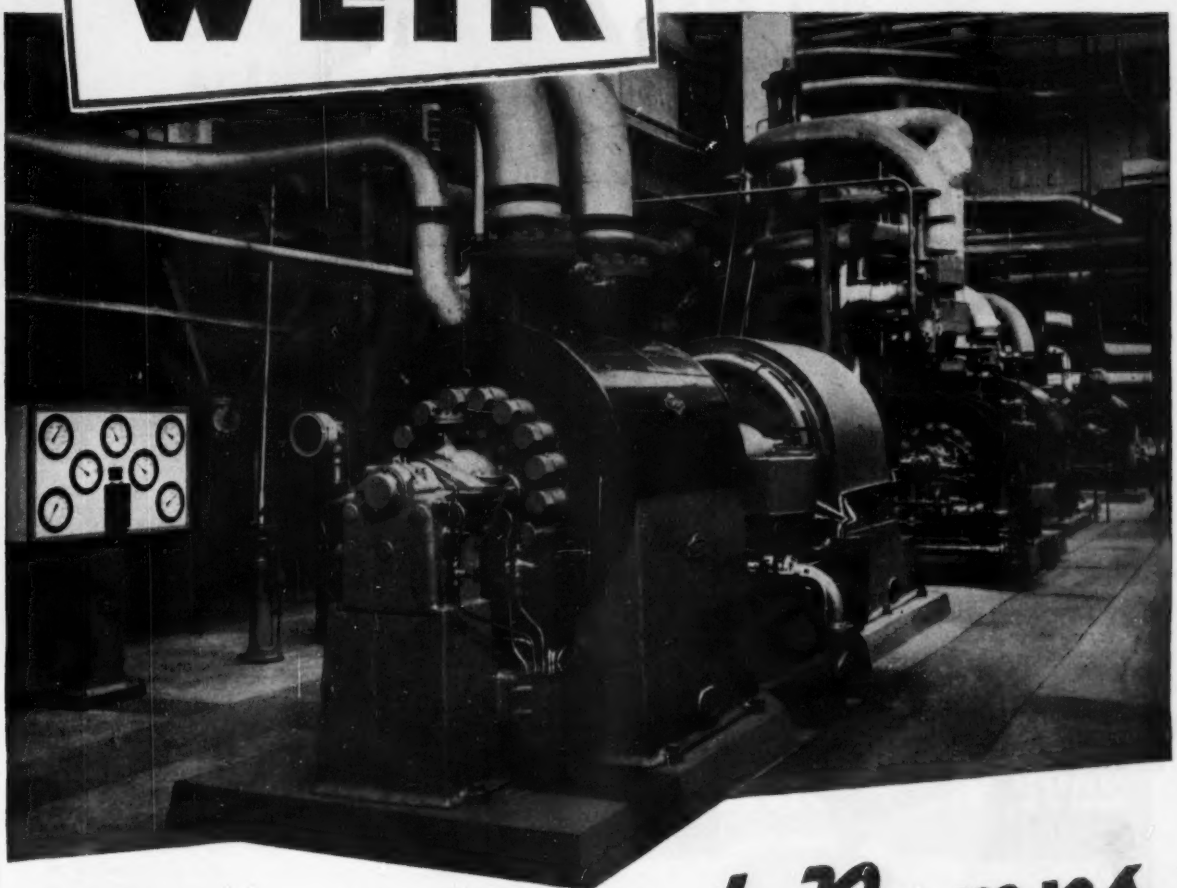
CALEDONIA ENGINEERING WORKS

PAISLEY SCOTLAND

London Office: 727, Salisbury House, London Wall, E.C.2.

Telephone: MONARCH 4756

WEIR



Boiler Feed Pumps

in single and multi-stage designs for the highest temperatures and pressures. Turbine and electrically driven pumps in ring section or barrel casing designs of the highest efficiency.

G. & J. WEIR LTD.
CATHCART · GLASGOW

FEED HEATERS · DE-AERATORS · REGENERATIVE CONDENSERS
EVAPORATING & DISTILLING PLANTS · HEAT EXCHANGERS

BABCOCK

Refinery Equipment

Right: Fusion-welding the longitudinal seam of a pressure vessel at the Renfrew works of Babcock & Wilcox, Ltd.

Below: Routine X-ray examination, applied to every inch of weld, shows less than 10 inches defective in every *mile*.

BOILERS

WELDED PRESSURE VESSELS

HEAT EXCHANGERS

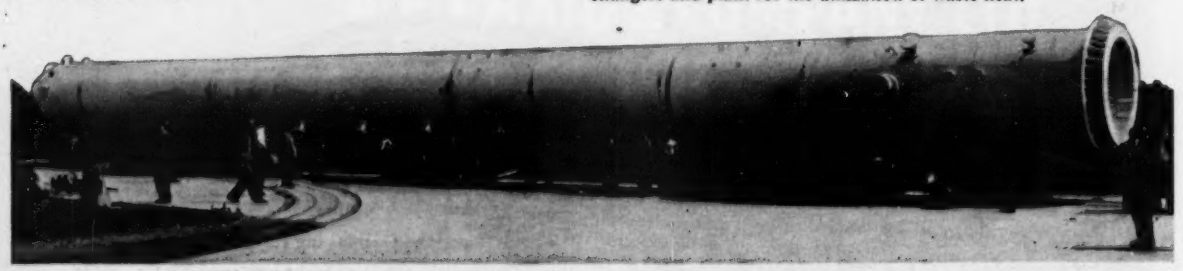
WASTE-HEAT UTILIZATION PLANT

CRANES

The picture above symbolises an experience of over 20 years in the manufacture of fusion-welded pressure vessels, a process that was pioneered by Babcock & Wilcox and developed by them to its present state of perfection.

The operator is supervising the automatic welding of a longitudinal seam in a large pressure vessel—maybe the high-pressure drum of a Babcock boiler, a high-pressure manifold or part of a large treating tower destined for one of the world's new oil refineries, many of which have Babcock equipment.

With 75 years of boilermaking experience, including their 23 years development of the fusion-welding process for the manufacture of pressure vessels, Babcock & Wilcox are outstandingly well equipped to meet the demands of the oil industry for complete modern steam-raising plants, treating towers, high-pressure manifolds, heat exchangers and plant for the utilization of waste heat.



BABCOCK & WILCOX LTD · BABCOCK HOUSE · FARRINGDON STREET · LONDON · E.C.4

FOR OIL REFINERY & CHEMICAL PLANTS

Special Two-hole Reducing Terminal with Flanged Side Outlet.

MILLENNIUM KEY

Millennium—Key Cast Steel Fittings

FOR STRENGTH & PRESSURE TIGHTNESS

These four bulletins give full technical information on each type of fitting we can supply. Please write for them.

Lake & Elliot Ltd.

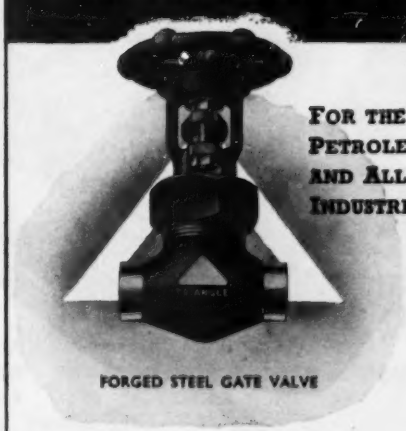
BRAINTREE ENGLAND

4382D

ADVERTISERS

Babcock & Wilcox Ltd.	xiv
Baird & Tatlock (London) Ltd.	ii
Baker Oil Tools Inc.	xviii
Birmingham Battery & Metal Co. Ltd.	Apr.
Peter Brotherhood Ltd.	May
W. P. Butterfield Ltd.	May
A. F. Craig & Co. Ltd.	xii
Dorman & Smith Ltd.	Apr.
English Drilling Equipment Co. Ltd.	iv
Evershed & Vignoles Ltd.	vi
Foster Wheeler Ltd.	xi
Foxboro-Yoxall Ltd.	v
W. J. Fraser & Co. Ltd.	May
General Refractories Ltd.	Apr.
Matthew Hall & Co. Ltd.	i
Hayward-Tyler & Co. Ltd.	May
F. A. Hughes & Co. Ltd.	May
Hydronyl Syndicate Ltd., The	Apr.
Wm. Kenyon & Sons Ltd.	vii
Richard Klinger Ltd.	iii
Lake & Elliott Ltd	xv
Lincoln Electric Co. Ltd.	May
A. & J. Main & Co. Ltd.	May
Metal Propellers Ltd.	May
Metropolitan-Vickers Electrical Co. Ltd.	xvii
L. A. Mitchell Ltd.	May
A. P. Newall & Co. Ltd.	*Back cover*
Newman, Hender & Co. Ltd.	May
Power-Gas Corporation Ltd., The	May
Pulsometer Engineering Co. Ltd.	x
Quasi-Arc Co. Ltd.	xvi
Rubery, Owen & Co. Ltd.	May
South Durham Steel & Iron Co. Ltd.	May
Triangle Valve Co. Ltd.	xv
Universal Oil Products Co.	viii & ix
G. & J. Weir Ltd.	xiii
Henry Wiggin & Co. Ltd.	*Inside back cover*
Woodfield Hoist and Associated Industries Ltd.	May
Yorkshire Copper Works Ltd., The	May

TRIANGLE Valves



FORGED STEEL GATE VALVE

FOR THE PETROLEUM AND ALLIED INDUSTRIES

FORGED STEEL

Screwed Ends. Sizes ¼" to 2". Pressures from 150 to 1500 lbs. per sq. in.

Flanged Ends. Sizes ¼" ⅜" 1" & 1½". Pressures 150, 300 & 600 lbs. per sq. in.

CAST STEEL

Flanged Ends. Sizes 2" to 12". Pressures 150, 300 & 600 lbs. per sq. in.

TRIANGLE VALVE CO. LTD.

Phone: 82631 (6 lines) Telegrams & Cables: TRIVALVE, WIGAN

LAMBERHEAD GREEN - WIGAN - ENGLAND

QUASI-ARC'S GREAT ARC WELDING

to all engineers

Arc Welding must always be well abreast of developments in the industries it serves: for today welding is much more a precise science than an engineering application.

The technical resources of The Quasi-Arc Company are virtually unrivalled. Specialised departments cover all contingencies. Technical Service Department which gathers and transmits the tremendous accumulation of knowledge from the other departments, is of particular interest to users to whom this knowledge and experience is freely available.

Quasi-Arc
REG. TRADE MARK

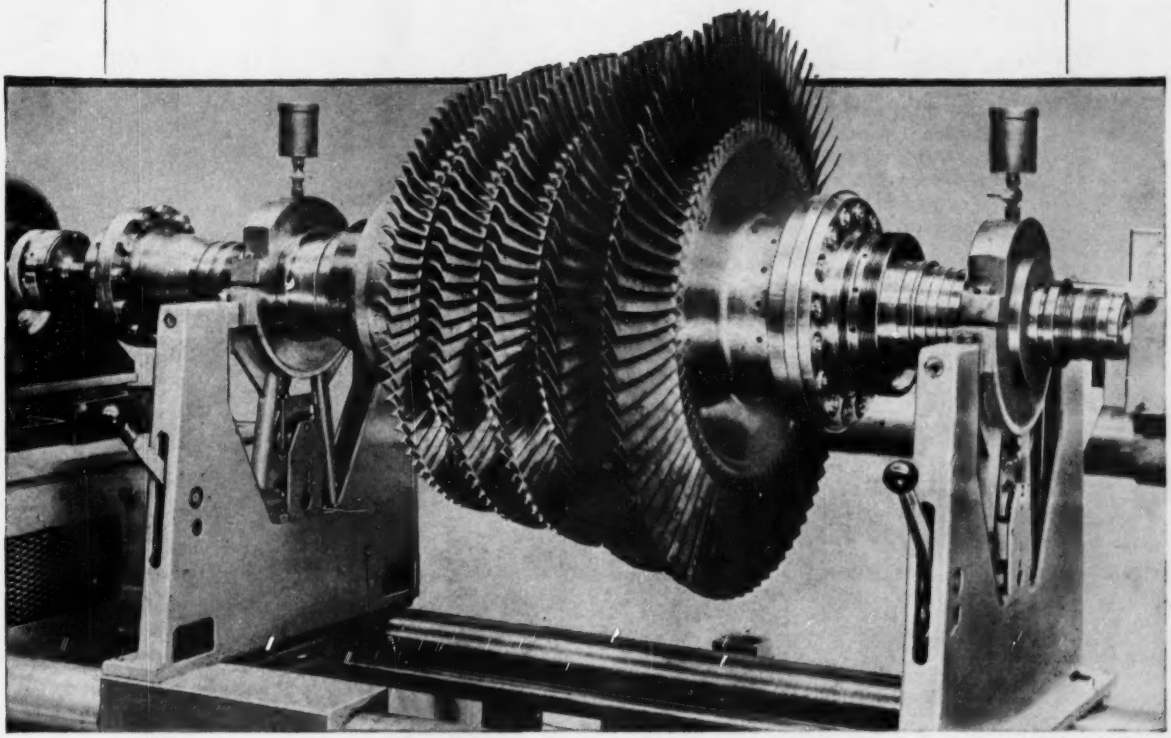
THE QUASI-ARC COMPANY LTD

Bilston • Staffordshire • England • Telephone: Bilston 41905 (6 lines)

Manufacturers of Electrodes, Plant and Accessories for Electric Arc Welding

QA36

Gas Turbines for Power Generation



Turbine Rotor in balancing machine

The 1,750/2,500 kW gas turbine Type L21 is one of a range manufactured by Metropolitan-Vickers for power generation. These robust and simple single-shaft machines have been built for standby and base load operation on liquid and gaseous fuels.

As leaders in gas turbine development, Metropolitan-Vickers would be pleased to give you advice and information.

METROPOLITAN-VICKERS
ELECTRICAL CO LTD TRAFFORD PARK MANCHESTER, 17

Member of the A.E.I. group of companies

Progress in Power Generation

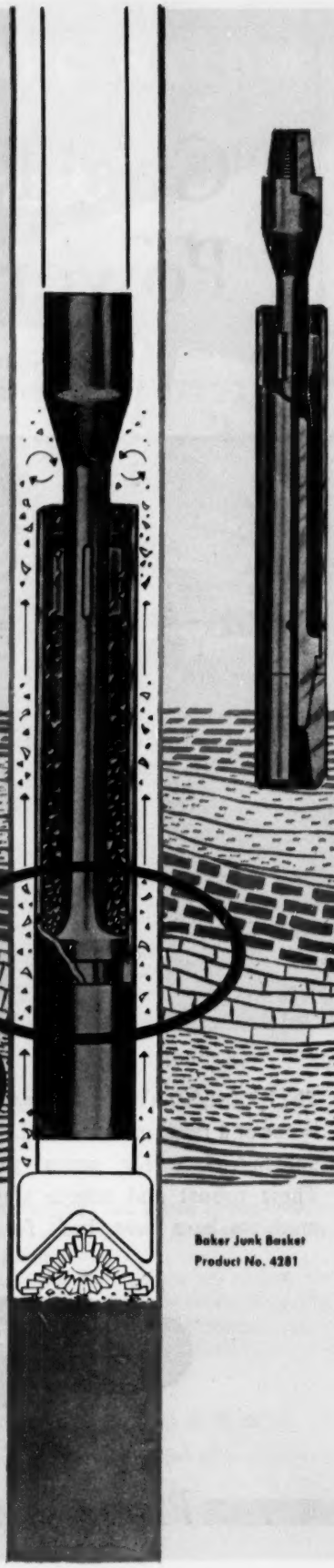
4339

THE BAKER JUNK BASKET safely traps, retains and removes from the well cuttings from "drilled-out" cast-iron, aluminum alloys, bronze or other dense, but "drillable" materials. Its design is simple and sturdy, and is readily understood by referring to the sectional illustration (upper right). Between the short Drill Collar (top) and the Drill Collar Sub (bottom) a Cylinder is mounted to provide a basket for trapping a considerable quantity of metal cuttings. When drilling out Baker Cement Retainers, Baker Bridge Plugs, Baker Production Packers, or other devices made of cast iron, aluminum alloys and similar "drillable" materials, a Baker Junk Basket (Product No. 4281) is positioned just above the rock bit, or diamond point bit.

SIMPLE, POSITIVE OPERATION—Cuttings from the drilling bit are carried upward by the high velocity of the circulation fluid through the comparatively small annulus around the Cylinder (see illustration). Now note how the annulus is *abruptly enlarged* due to the smaller diameter of the Drill Collar. When the circulation fluid reaches this enlarged annulus the velocity of the fluid is so greatly reduced that the cuttings are no longer carried upward, but drop into the basket (Cylinder) where they are trapped and recovered when the Junk Basket is removed from the well.

catch those metal cuttings with a...

BAKER JUNK BASKET



Baker Junk Basket
Product No. 4281

AVAILABLE IN POPULAR SIZES—The Baker Junk Basket is furnished to make up in 2⅜" to 4½" A.P.I. drilling strings to run in 4½" to 9⅝" A.P.I. casing. Any Baker representative or office will recommend the proper size for your needs, and see that you are supplied promptly on a low-cost rental basis. Specifications for purchase by overseas operators can be found in the BAKER (or Composite) CATALOG.

BAKER OIL TOOLS, INC.
HOUSTON • LOS ANGELES • NEW YORK

Look at it this way

Wiggin Nickel Alloys are being used in so many different ways, wherever heat and corrosion raise problems, that it is almost impossible to keep abreast of all developments. Our periodical, 'Wiggin Nickel Alloys', illustrates some of the new and unusual uses of wrought high nickel alloys, and gives technical data to assist designers to apply these materials to the best advantage. We shall be pleased to add your name to our mailing list for regular receipt of copies.

By courtesy of Sunderland and South Shields Water Company.

Mill Hill reservoir, Durham, is being lined with rubber to prevent leaking. Here a worker is fixing the rubber sheet to corrosion-resistant Monel bolts, secured in the sides of the reservoir by 'Bolt Anchors' made by the Rawlplug Co. Ltd.

An extract from one of the articles in the current issue of Wiggin Nickel Alloys.

To Henry Wiggin & Company Limited, Publications Department, Wiggin Street, Birmingham 16.
Please send me, free of charge, a copy of the latest issue of Wiggin Nickel Alloys, and add my name to your regular mailing list.

Name .....

Address .....

HENRY WIGGIN & COMPANY LIMITED • WIGGIN STREET • BIRMINGHAM 16

Unique

"Newallastic" bolts and studs have qualities which are absolutely unique. They have been tested by every known device, and have been proved to be stronger and more resistant to fatigue than bolts or studs made by the usual method.

G. P. Newall & Co., Ltd.

POSSILPARK GLASGOW · N